RAILWAY ENGINEERING
AND MAINTENANCE OF WAY.
BRIDGES—BUILDINGS—CONTRACTING—SIGNALING—TRACK
Published by THE RAILWAY LIST COMPANY

WILLIAM E. MAGRAW, Pres. and Treas.
CHAS. S MYERS, Vice-Pres. C. C. ZIMMERMAN, Bus. Mgr.
NORMAN F. REHM, Editor J. M. CROWE, Mgr. Central Dist.

Office of Publication: 315 Dearborn Street, Chicago
Telephone, Harrison 4948
Eastern Office: 50 Church Street, New York
Telephone, Cortlandt 5765
Central Office: 403 House Bldg, Pittsburg

A Monthly Railway Journal

Devoted to the interests of railway engineering, maintenance of way, bridges and buildings.

Communications on any topic suitable to our columns are solicited.

Subscription price, $1.00 a year; to foreign countries, $1.50, free of postage. Single copies, 10 cents. Advertising rates given on application to the office, by mail or in person.

In remitting, make all checks payable to the Railway List Company.

Papers should reach subscribers by tenth of the month at the latest. Kindly notify us at once of any delay or failure to receive any issue and another copy will be very gladly sent.

Entered as Second-Class Matter April 13, 1905, at the Post Office at Chicago, Illinois, Under the Act of Congress of March 3, 1879.

Vol. VII. Chicago, January, 1911 No. 1

CONTENTS

Editorial 1, 2
Coal Tar 2
Timber Preservation 6
Maintenance of Way Department—
Killing Weeds 14
Winter 14
Switch Stands 14
Construction 15
Fast Railroad Construction 16
Eucalyptus Obliqua Ties 16
Imperial Valley 16
Personal Injuries 16
Personal 17
Shop Extension, C. & N.-W. 17
Signal Department—
The Santa Fe 20
Signaling on Electric Railways 26
Booth Water Softener 36
Shaw Blueprint Machine 36
A Large Block 37
Railway Appliances Association 37
Wire Rope Protection 38
Perry-Prentice Automatic Stop 38
Railway Business Association 38
Block Signal and Train Control Board 39
Explosion at Grand Central Terminal 50
Motor Cars 50
Upper Berths 51
Jamaica Passenger Station 51
Signaling Notes 51
Mine Rescue Stations 52

ARBITRATION.

CONGRATULATIONS to the western general managers and the Brotherhood of Locomotive Engineers on the sensible method employed to settle their differences. Public opinion no longer sympathizes with strikes, those who provoke them or those who participate in them. War is becoming unfashionable.

AN ERROR.

LAST MONTH we published the views of Mr. J. J. Hill on the railroad and commercial outlook in general. With the best intentions in the world this clipping, or the first part of it, was placed on the editorial page. It was by no means our intention to convey the impression that our views coincided with those of Mr. Hill, yet this is exactly what some people thought. We therefore take this, our earliest opportunity, to assert that such an idea is absolutely erroneous.

MARCH.

PORTRAITS WILL be a feature of our March number this year as heretofore. Our special de luxe edition for that and the succeeding month will later be issued bound in cloth to serve as a permanent record and souvenir of the Maintenance of Way and Signal conventions.

WHAT HAVE THE EMPLOYES TO SAY?

SOME TIME AGO we quoted an editorial from the *Chicago Daily Tribune* on the subject of freight rates and we now have occasion to do so again, though this time we make no comment; we merely suggest that what follows is well worthy of thoughtful consideration by all concerned, the public, the railroad employes and managers, and the shippers. The heading is the same as that over the original editorial:

> We are not through yet with the discussion of Mr. Brandeis' contention that the railroads could save a million dollars a day. James O. Fagan, the author of "Confessions of a Railroad Signal Man," agrees fully with Mr. Brandeis that such a saving is possible, but rebukes him for failing to point out why scientific methods have not been introduced into the specific departments where he would have them tried.
>
> According to Mr. Fagan the efforts of the roads in that direction have failed invariably because of a "stone wall of opposition from organized labor," which discountenances the recognition and reward of extra exertion and merit. Thus the effort of President Mellen of the New Haven road to introduce scientific management which would have effected great economies "was pitted against the wishes of labor and the apathy of the public, and the latter won." Mr. Fagan tells Mr. Brandeis that if he were to be specific and advocate the introduction of scientific methods in the shops of the New Haven road, he would become the most unpopular lawyer in New England.
>
> There is an opportunity for railroad economies outside the shops. Mr. Fagan quotes a western railroad president to the effect that preventable accidents on the roads cost the people $125,000,000 a year. Of the accidents, according to this president, 85 per cent is due to the negligence of employes. The equipment, said he, was not to blame, but the human element, which had not been properly taught. Wherever the blame may rest it is a fact that the bills paid by the railways on account of damages make a formidable inroad on their revenues.
>
> Thus far "organized labor" and the railroad employes have kept out of the discussion. Now they have been drawn into it. They are charged with making shop economies impossible and with responsibility for most railroad accidents with their loss of life and property. Now it is time for their representatves to give the employes' side of the case. Also we may expect to hear further from Mr. Brandeis, who is rather roughly handled by Mr. Fagan.

We might add that this throws an interesting light on the thoroughness with which Mr. Brandeis has gone into the subject.

WASTE.

NOT VERY LONG AGO the chief and 23 firemen of the Chicago fire department lost their lives in the collapse of a burning building in the Stock Yards district. Deplorable as such needless sacrifice of human life is, yet there was and always is in great disasters another, and to the nation as a whole, a more serious loss involved. Being a sentimental and individualistic people, the "human interest" element in all such tragedies appeals to us and commands our attention to the exclusion of the economic aspects. Involved in this fire was the destruction of a large amount of meat. This means not only that a certain large economic loss was sustained by the community through the destruction of resources, but that there is a definite amount of food less in the world now than before the fire, and this food and its value can never be replaced. Looked upon from this point of view the fire was a crime against nature, for nature, while careless of the individual, is yet very careful of the species, and the food supply is of vital interest to the species. We will not enlarge further upon this subject except to say that the supposition that since such losses are covered in general by insurance, there is in reality no

loss is one of the worst fallacies of this age of commercialism. For the premiums paid or money set aside for insurance purposes and later used to replace property destroyed is thereby withdrawn from other useful work; it might otherwise be used, for example, to build additional railways, or enlarge existing plants.

We will merely notice in passing on, the fact that the corporation, part of whose plant was destroyed, is a member of the Illinois Manufacturers' Association and a large shipper. Efficiency in management, like charity, should begin at home. Fireproof buildings, or at least steel supported floors and a sprinkling system capable of flooding the buildings might have worked wonders in economy.

SINGLE TRACK OPERATION.

SIGNAL ENGINEER A. H. RUDD of the Pennsylvania, in describing an installation on his road, at a meeting of the Canadian Railway Club recently spoke in part as follows:

"We have an installation of about 14 miles on the Western division, running west from Williamsport to Erie, of single-track manual controlled signaling. We have had it in service for some three years. We use the permissive block for following trains. While we could build a second track, the present location is not favorable, and the construction of a new double-track line would be very expensive. The system is so arranged that, if a train enters a block, no signal may be given in the opposite direction until the train clears the block, either by passing through or by entering a passing siding, and then only when the train is into clear and the switch locked, but a permissive signal may be given for a following freight, absolute block being used for passenger trains. After a train is locked in on a siding it cannot get out until a following train has passed the switch, and the switch is unlocked by the operator, or until an opposing train has passed the meeting point. It is not, however, necessarily held on the siding until the trains referred to have passed entirely out of the block. It is practically the same thing that we are using between Broad street station and the Schuylkill river, Philadelphia, where we operate eight tracks in either direction. It seems to me it is a great development, and I do not believe our people would think of putting in a staff in place of this lock and block system."

The reason that such a system is superior to the staff is that it is not necessary for a train to pick up, or put off anything, and no special apparatus, as staff catchers, need be applied to the engines in order to operate at high speeds. Otherwise the staff system can be made to accomplish all that Mr. Rudd claims for his installation.

However, the point we wish to bring out is not the relative merits of two systems, but the fact that with one adjunct not mentioned by Mr. Rudd his system would be perhaps the safest and most flexible ever devised for single-track operation. That one adjunct is the automatic block signal. With automatic block signals added, so arranged as to give rear end protection only, trusting to the controlled manual apparatus for head-end protection, the system would be complete. In this way the blocks between stations could be divided to accommodate dense traffic without the necessity of letting two trains into the same block on permissive signals, the method of procedure being the same as with automatic block signals on double track.

The meat of the matter is this: It is safe and feasible, and not expensive, to operate trains on single track without train orders. There are several systems.

THE SIGNAL DEPARTMENT.

THE SANTA FE signal standards, which we publish this month, show, among other things, how concrete is displacing other materials of construction in all fields. We refer particularly to the cable post which appears to be a substantial and cheap device, in every respect capable of fulfilling all requirements. It seems, however, that the concrete idea is being carried to extremes in the matter of combination foundations. The highest development of all (combination battery box, foundation, chute, cable and relay post) must be a fairly expensive affair in itself, though the cost would no doubt be warranted for a permanent structure. But it is the sad experience of railroads that signal arrangements are not permanent, far from it, and it would seem a shame to have to abandon such a structure while yet in good condition. Should the various component parts be susceptible of separation, all but the foundation proper could be moved with the signal to a new temporary abiding place. However, the design is ingenious and reflects credit upon the designer.

COAL TAR—ITS PRODUCTS AND USES.

By William W. Bowman.

Prepared Under the Auspices of the International Lecture Institute.

In the case of refined tar, if it is heated too much in manufacture, the life-giving oils are removed and the resulting product becomes too thick, while, in other cases, if not sufficiently refined, the product is too thin, having too many of the heavier or lighter oils in it. It will, therefore, be seen that an absolutely uniform product is essential to good work.

Refined tars are used for various purposes, among them road treatment. They are also used for the saturation of roofing felt, the manufacture of preparations known as roof paints for waterproofing walls and cellars, varnishes, tar concreting for sidewalks, sub-floors, roofing, coating, fire-resisting paints and many other uses, which are too numerous to mention here.

While the treatment of macadam roads abroad with tar preparations has been practiced for many years, its introduction into this country is comparatively recent. In 1903 the first macadam roads were treated in this country with a tar preparation. The treatment was so successful that hundreds of miles of macadam roads are now treated yearly in this country. When properly applied the tar binds the surface of a macadam road together so that it is practically waterproof. After a heavy rain such a road will be dry, when those not treated will be muddy. The roads properly treated are, as before stated, bound together and are practically free from dust; the reason being that the tar, in connection with the road material, produces a tar concrete on the surface which resembles asphalt, possessing a slight cushion or elastic surface which prevents to a large extent the wear of these roads by ordinary traffic.

Effects of Self-Propelled Vehicles.

One merely has to examine an ordinary macadam road after a heavy day's traffic by motor cars to see the loose, friable and disintegrated condition of the surface. Tar macadam subjected to the same usage will be, as far as one can see, not a scrap the worse, and if there is one class of traffic which tar macadam will unquestionably bear and resist, it is the traffic of motor cars with resilient tires.

So far as scarifying by steel-studded tires is concerned, the terrible action of such tires, which can only be likened to fast-revolving cog wheels, are ruinous to any ordinary macadam road. But it must be admitted that they owe their origin to the conditions of the macadam road, to the mud that is produced and exudes upon the surface. While steel-studded tires are found not to have the same detrimental effect on tar macadam, there would be, by reason of the absence of mud and dust as a consequence upon the general introduction of tar macadam, no necessity for the utilization of the scarifying types.

Tar Roofing.

Tar-saturated felt is supposed to have been first made in Germany. Sheets of felt were dipped by hand into a vessel of hot tar and, after drying, were fastened on the roof in successive layers, as are shingles or tiles. Also the dry felt was laid on roofs and fastened, and then saturated with tar *in situ*.

These methods were pursued in the United States in the early days of the industry, and are still followed in parts of Europe. Such crude methods are necessarily expensive and yield results lacking in uniformity, but with the extension of the industry came improved appliances and methods.

The dipped sheets came to be passed between metal rolls, to make the saturation uniform and produce a smoother and tougher paper. Later machines were adopted which took the dry felt in rolls, passed it through the saturating bath and delivered it in rolls of suitable size. In the development of mechanical devices for performing this work the Americans have gone far ahead of other countries, as has so often been the case, and with the perfection of the machinery for the process has come a large increase in the amount of the product as well as the ability to maintain a uniform quality within narrow limits, and, therefore, to adapt the product to a wider range of uses. The output of tarred felt in the United States is now many times greater than that of Germany, the nearest competitor, and the field of its application is much more extended. Roofing and waterproofing of tarred felt and pitch in some form are in use in every city, town and village in this country.

The sky lines of two of the largest cities in the United States, New York and Chicago, are worth looking at. They show the finest specimens of modern architecture and engineering in the world, as applied to commercial buildings, and the land upon which they stand represents hundreds of millions of dollars. Within there are found the largest and most influential corporate and business interests in the world. What more convincing proof can be given of the value of coal tar products than the fact that practically all of the buildings in these sky lines are roofed or waterproofed with tarred felt and coal tar pitch? On some of the modern fireproof buildings the roofs are finished with a course of vitrified tile or brick, laid in Portland cement, over five-ply tarred felt and pitch, but the majority are finished with a covering of slag or gravel. It is a well known fact that there are hundreds of roofs in this country covered with coal tar felt and coal tar pitch have been in use for twenty years or more with practically no expense for maintenance during that time.

Machinery.

The modern saturating machine takes the raw felt in huge rolls, weighing as much as 600 pounds each, saturates it and automatically winds it in rolls of measured length, the rate of passage through the saturating bath, the temperature of the tar, the quality of the dry felt, the necessary complete penetration of the felt by the tar and the final weight per square foot of the finished product all being objects of careful specifications and close supervision. Tarred felt and pitch are splendid waterproofing materials. To discuss properly the use of tarred felt and pitch in waterproofing, the separate function of each should be clearly understood. It cannot be too strongly emphasized that the ability of the combination to resist the penertation of water for any considerable time is due to the pitch, and to it alone. The tarred felt acts as the retaining, supporting and protecting medium. Tarred felt alone will, it is true, resist water, and it is frequently used for this purpose on temporary work, but its somewhat porous structure and the lack of viscosity or body that the saturating bath must possess in order that it shall penetrate the felt thoroughly, prevents tarred felt alone from having the waterproof quality under the protracted service that a coating pitch assures.

But pitch alone, in a layer of sufficient thickness to form a permanent and weather-resisting coating, would inevitably run, if applied on a slanting or vertical surface, and would gather in the lower places, leaving the rest bare of the proper covering. This is avoided by placing the pitch in successive thin layers between sheets of tarred felt, to which it strongly adheres, and which, in combination with it, form a waterproofing envelope of unsurpassed durability under the most trying conditions of exposure. The union of the pitch and tarred felt is much aided by the fibrous nature of the latter and by the presence in it of the saturating compound, which, being of the same nature as the pitch, but of more fluid consistency, tends slightly to soften the pitch and cause it to penetrate the felt more deeply than could be otherwise expected.

So intimate is the union of pitch and felt when properly put together that, if a section of roofing or waterproofing be cut through with a knife, the felt and the intervening layers of pitch will be found to be almost indistinguishable and practically inseparable. The pitch has interpenetrated the felt, and the fibers are imbedded in it, so that the function of the fibers may be likened to that of hair in plaster. They furnish the cohesive strength which the plastic material would otherwise lack. Therefore, the basis upon which a proper use of coal tar pitch and saturated felt as waterproof materials rests consists in regarding an unbroken layer of pitch as the essentially waterproof agent and using saturated felt as an aid in the construction, maintenance and protection of this waterproof layer.

Once these fundamental facts are recognized, the quality of the materials, the best practical methods of applying such a waterproof envelope and the proper number of layers or plies required under various conditions may be intelligently discussed. Beyond any question the best method of doing such work is to build up the fabric in its final place, using tarred felt prepared for this purpose and melting and applying the pitch as it is required. Satisfactory results, it is generally conceded, can only be obtained when the pitch is distilled direct from the crude tar, without being first made into hard pitch and softened or "cut back" with tar or other oils to the proper consistency, as previously explained.

A material that will withstand the corroding and dissolving influence of the elements for ten, twenty or even thirty years, or that will remain unchanged and efficient in foundations for an indefinite period, demands care and skill in its preparation. So carefully are the various requirements considered that not only does each purpose have assigned to it a pitch of special consistency, but this consistency varies according to the season of the year, that for winter different from that for summer.

As I have already said, the use of an outer layer of gravel imbedded in pitch was one of the earliest improvements made in tarred felt roofing. It was also one of the most important, as the wear on a roof is practically all due to the corroding action of the elements—sun, rain and wind. Under their influence the pitch coating of the earlier roofs gradually wasted away, and the felt was left exposed to the weather. This statement should not be taken to mean that pitch is soluble in water. On the contrary, it is the least soluble of all bituminous materials. Stone, wood, concrete, iron are all insoluble in water, yet all suffer gradual erosion by weather.

Of all the materials economically available for weather-resisting purposes, stone is conceded to be the best. Therefore, to give a roof of tarred felt and pitch a wearing surface of small pebbles firmly imbedded in a matrix of pitch was a natural and logical expedient. Moreover, the presence of the gravel made it possible to retain more pitch on the roof by stiffening the mixture and making it less liable to run, thus further adding to its durability. The gravel roof, which was thus evolved has been favorably known for upwards of fifty years.

The adoption of the stone surface eliminated the expense and trouble of recoating which was necessary for roofs of tarred felt alone at more or less frequent intervals, and increased the life of the roof to as much as thirty years, with-

out repairs or attention of any kind being necessary during that time. But it is not alone as a wearing surface that the gravel or slag surfacing is useful. It has a fire-retarding effect of no mean value. When exposed to a rain of burning embers from a fire nearby, the non-conducting particles of stone hold the hot coals away from the wood beneath and minimize the effect on the tarred felt. Such a roof has repeatedly proved itself as non-combustible as one of tin or of other metal, and, if laid over boards, it is a better protection to them because it is a non-conductor.

Resultants from the Distillation of Coal Tar.

In the distillation of coal tar the tar itself is placed in a large still or boiler, holding approximately ten thousand gallons. After the fire is started in this the tar almost immediately begins to give off its vapors, which are condensed and return into liquid form. The first of these vapors that come off are the oils lighter than water, or, in other words, those having a boiling point of water, which is 212 degrees F. From these oils are made benzols, naphthas, which, by the way, should not be confused with the products known as benzine and naphtha distilled from petroleum. The benzols are used extensively as solvents for rubber, in the making of artificial products, paints, stains, varnish removers, enamel paints, thinners for varnishes, turpentine, polishes and a variety of other uses. The naphthas are used in the manufacture of ship bottoms, paints, thinning coal tar and other black paints. The next oils to come off are those heavier than water, and are known as heavy, dead, or creosote oil, carbolic oils, etc.

Creosote Oil.

Creosote oil, which is also called in the trade dead or heavy oil, is used extensively throughout the world for creosoting purposes. The methods of creosoting timber vary greatly according to the purposes for which the timber is to be used. Where large timbers for telephone poles, cross bars, railroad ties and wood blocks for street pavement, etc., are to be treated, a special plant is necessary. The timber is first introduced into a large cylinder and by vacuum the sap or moisture is extracted therefrom. The wood is then thoroughly heated and dried and put into another large cylinder, where it is immersed in creosote oil, the oil being forced by great pressure into the timber. This method insures a perfect and complete penetration of the timber.

Where a surface treatment only is desired, a comparatively inexpensive outfit only is necessary. In some cases, such as in the treating of small fence posts, a cold treatment is all that is usually given. A special preparation for this is now made, known as creo carbolene. This can be applied either with a brush or by having a small tank in which to immerse the article to be creosoted.

The creosote, or dead oil, contains a large percentage of what is known as naphthalene, which becomes solid below certain temperatures and from which moth balls, etc., are made. In order to keep this naphthalene in a liquid state it is necessary to heat the creosote oil, in order that the naphthalene may remain liquid during the treatment of the wood.

Carbolic Oils.

These are the oils from which the well known carbolic acids are made. The acids are made in a great variety of strengths and in varying colors, according to strength; the pure liquid acid being water-white at the time of manufacture. The absolutely pure acid, however, is a crystal, which is a solid below certain temperatures.

An interesting feature in connection with these acids is the fact that when they are being made they are in liquid form and, of course, heated. As they cool, however, and reach a certain temperature, they instantly change from a liquid into a crystal, and when the liquid is put into bottles and left to cool, the change is so sudden as sometimes to make the bottles move on the bench where they are filled. After distilling off these light and heavy oils, there is a residue left in the still known as "coal tar pitch."

Coal Tar Pitch.

This pitch, as has been previously explained, is the residue left in the still after boiling off the lighter and heavier oils and is made of many consistencies for different purposes. It is probably one of the most interesting articles produced in coal tar, to the average person, for the reason that it has so many different uses. A few might be named here.

First: As before stated, for use in connection with tarred felt or applying slag on gravel roofs.

Second: As a paving pitch.

Just as great care and study are now given to the foundation, whether of sand or hydraulic concrete, on which the pavement rests, so also is the attention of the street paving experts more and more called to the vital need of a good filler or binding material which will hold the paving blocks tightly together and prevent water, filth, etc., passing through and destroying the foundation. The increasing and heavier traffic of to-day demands both.

In choosing a filler for a brick pavement, the following questions should receive consideration. It appears as though tar pitch is especially suitable for this class of work: 1. Is it absolutely waterproof? 2. Is it permanent? 3. Does it provide for expansion? 4. Does it provide for contraction? 5. Will cracks be avoided? 6. Does it leave sufficient joints for foothold? 7. Is it easy to use correctly? 8. Can pavement be used immediately? 9. Can the pavement be cut for repairs, etc., without destroying the blocks?

The tar paving pitch has been used as a "filler" for stone, brick and wood-block pavements for over forty years, and has proved a satisfactory binder for the wearing surface of the pavement and for a filler for waterproof protection of the foundation. Tar does not disintegrate under the action of water, and is elastic and pliable, completely fills up the interstices and is long lived. On account of the inherent qualities of this tar product it allows for expansion and contraction and there are many claims for its indestructibility and its noise-muffling effects, which are demonstrated by actual experience. For successful use it must be so combined and treated in refining and manufacturing as to have a fixed melting point within certain limits.

Third: Waterproofing.

It is a fact well known to all chemists and engineers that coal tar pitch remains absolutely unchanged in water. Therefore, where the foundations of the large buildings established in and about New York city are waterproofed, coal tar pitch is most generally used in connection with tarred felt. In many of these buildings the tide water rises about the foundations, but, in spite of this, the inside of these cellars and walls are as dry as if above ground. There is no other known material for waterproofing purposes that remains so unchanged by water as pitch. It is also used in waterproofing tunnels constructed below the river bottom.

A noticeable example of the value of coal tar pitch for waterproofing is the roof of the New York Central tunnel, Park avenue, in New York city. The waterproofing material of the roof has recently been removed in order to make room for certain improvements in connection with the Grand Central terminal station. The waterproofing felt and pitch in this work had been underground for about thirty-two years and was only of about four-ply. To-day seven, eight and ten ply are recognized as the proper grades in work of this kind. When this waterproofing was removed it was found to be absolutely perfect and unchanged and contained as good waterproofing material when taken out as when first applied.

In general the complete waterproofing and resisting of water pressure is attained by alternate layers of pitch and felt, which are then reinforced by concrete. When the waterproofing of the floor surface is completed, it is covered with concrete of such mass, weight and strength as will enable it to resist any pressure. It is a continuous seal or lining, covering the entire floor and extending up the walls to a point above the water line.

In the treatment of walls, coal tar pitch and tarred felt are applied to some form of masonry or concrete; if rough stone, the surface to be waterproofed must be plastered fairly smooth to receive the waterproofing, which consists simply of, first, a coat of pitch, applied hot with a mop, then a layer of tarred felt with alternating layers of pitch and tarred felt until the requisite number are solidly and securely in place. The number of courses varies with the character of the work, from ten plies in a water-pressure operation to two or three where only the ordinary dampness of the earth is to be excluded.

Fourth: For making electric carbons.

Most all of you are familiar with the small electric dry cell used to produce the spark of automobile or gas engines, as well as for use on electric bells. You will also notice that the center of battery has raised portions, which most of you know as carbons. This is made entirely from pitch. The battery itself is sealed over with pitch.

Fifth: Coal briquetting.

In many foreign countries and in parts of America there are coals produced which are so poor that they cannot be burned in their original state. Furthermore, in the anthracite coal regions there are large mountains of coal dust which have been accumulating for years past. There are now several factories in this country which take this coal and grind it into fine dust and mix with it a certain proportion of coal tar pitch. The mass is heated and run through a heavy press, which turns it out in small egg-shape or pillow-shape pieces, known as briquettes. These are about the size of the ordinary coal, such as is used in the kitchen range. This is becoming a great industry in this country and new plants are being talked of daily. In Germany practically all of the coal has to be briquetted before it can be used, and there are millions of tons treated annually in that country.

A fire made of coal briquettes produces a slight smoke when it is first ignited. After that the briquette burns with a steady glow similar to charcoal, without flame, but with intense heat, the outside burning off first and the briquettes becoming smaller as they are consumed. The ash from these briquettes is considerably less than from coal, and is like a fine powder. There are no clinkers or cinders. It is claimed by many that briquettes are far better for both household and steam use than coal, and in some localities they command a higher price.

Sixth: For records.

It may also be interesting to you to know that many of the talking machine records made to-day have as their base coal tar pitch. The surface, however, is made of finer material, but pitch is generally used as the body.

Seventh: For hard rubber substitutes, etc.

There are also various substitutes for rubber, such as mouthpieces for telephones, etc., made from coal tar pitch. There are many articles made from wood fibre to-day. Most of these are saturated with hot coal tar products to lend waterproofing qualities and to give strength.

There are also many kinds of black paints for iron work made by mixing pitch with a solvent and drier to produce the desired consistency. Such varnishes or paints dry with a fine luster and are excellent waterproof materials for iron work. There are also concerns in this country making wood pipe which is used extensively in mines where, on account of its expense or the action of the water, iron cannot be used, and in all such cases the wooden pipe is first dipped or waterproofed with pitch. As before stated, pitch is also used in connection with tar, sand or stone, in many cases, for sidewalks, driveways, foundries and cellar floors, etc.

Many of the under-water electric telegraph and telephone cables are waterproofed with coal tar pitch, both to prevent the water from reaching the cable and to prevent the current from leaking out, as it is an excellent insulator. In many of the large breweries and ice and cold storage plants they build a double wall with a space of about one inch or more between. This space is then filled with coal tar pitch to prevent the air from reaching the cool rooms, acting in this case as an insulator.

In all of the large foundries there is a product used known as "core compound." This is used in castings where a hollow space is desired. Pitch, in connection with other materials, has been found to make the best core compound that can be produced, and it is used in enormous quantities for this purpose to-day. These are only a few of the uses to which coal tar pitch is put. These uses, however, consume the greater part of the pitch produced in this country.

Improved Floor Construction.

In the construction of new freight houses, pier sheds, factories and machine shops, the question of the ground flooring is always of vital interest. In general a wooden floor is desired for many well known reasons, such as resiliency and dryness necessary for the health and comfort of men standing upon it, its adaptability to the fastening of machinery, smoothness for trucking and easy renewal of the upper surface planks. The expense of the upper supports to allow an air space between the earth and floor, the necessity for strength and rigidity, the short time the floor will last on account of decay, have caused other substances to be sought and sometimes used. There is also the fire risk to be considered, on account of the air space beneath the floor. If, to secure rigidity, the floor be placed upon the earth, its life is only a few years, and sometimes the decay seems to make great progress even within one year. Manufacturers have had bitter experience in the rotting of timber and plank in a relatively short period.

The floor must be rigid, and this requires underneath many cross girders or beams. Experience has demonstrated that floors, if imbedded in concrete, decay almost as quickly as if placed upon the earth. On account, therefore, of the short life, the expense of the sub-supports for the floor planks, difficulty in securing the rigidity without many supports, fire risks, these and many other reasons have caused the disadvantages to outweigh the advantages of wood floors, but coal tar pitch, with its wonderful properties, has nullified all these objections. By the use of tarred floorings the following favorable results are obtained:

First: Much less cost than where piers, heavy timbers and extra excavation are involved in the usual methods of flooring to give the necessary air space between the floor and the earth.

Second: Absolute rigidity and strength. Its strength only limited by the crushing strength of the planks.

Third: Excluding all air from below, making a fireproof construction.

Fourth: The coal tar prevents decay, and white ants and borers do not destroy the planks. Such floors are non-heat conducting, impervious to water, and, therefore, warm to the feet. Concrete or cement floors contain water in hydroscopic form, as seen in old cellars. They are ready conductors of heat and in many stages of the atmosphere become absolutely wet, probably from condensation of moisture from a warm atmosphere.

It is noted that the freight house of the Pennsylvania at

Springfield, Ohio, has this improved type of floor; in the Maine Central repair shops at Portland, Me.; in the spinning room of 70,000 spindles of the Arnold Print Works, Monquitt Mills, and they are now being specified by most engineers. The top tar mixture should be soft and of such consistency as to be firm and yet permit the creosote oil in the coal tar to act freely upon the wood as a preservative and an insect preventative. All the interstices in the lower layer should be carefully filled.

Conclusions.

It will be agreed from the foregoing that the coal tar industry is of the greatest economic importance to the United States. When it is realized that even saccharine is produced from tar, and that to-day imitation amber is also being made from the same material, there seems no limit to the uses to which it will ultimately be put. When it is further recalled that not many years ago tar was considered a noxious waste, the development of the industry in such a short space of time is almost incredible, and the promise for the future illimitable.

The Preservation of Structural Timbers from Decay.*

By C. P. Winslow.

Engineer in Wood Preservation, Forest Service.

The preservation of timber from decay by injection with chemicals, although largely practiced in Europe for many years, has only developed extensively in the United States within the past decade. Largely on account of the extensive supply of timber and the corresponding low cost, little attention to the conservation of the forests and their products was thought necessary. The consumer could see no immediate economy in increasing the initial cost of the product in order that a longer service might be secured. The supply was plentiful, and when timbers were rendered unfit for further service by decay and other destructive agencies, others could be readily and cheaply secured. Of recent years, however, these conditions have changed. With a diminishing supply and increasing demand for timber, there could be only one result—an increase in cost. In 1900, the average value for lumber at the mill was $11.13 per M. ft. B. M.; in 1908, it was $15.37, an increase of over 38 per cent in eight years. Correspondingly, the practice of wood preservation methods has increased. While in 1904, less than 30 treating plants were in operation, there are at present 78 either completed or under construction. This increase in plants of over 160 per cent in six years is only natural. The consumer is coming to the realization that for many cases there is no longer a question as to whether or not wood preservation will pay, but rather what method or process will give the best returns. There are, of course, a variety of preservatives and processes now used commercially, of which some are best suited for one purpose, some for another, and the selections must depend upon the features of each individual condition. There are, however, certain well-established principles upon which depends the success of any treatment. It is the purpose of this paper briefly to point out these principles and discuss the preservatives and processes now in general commercial use.

Wood Structure and Causes of Decay.

Before considering methods for preventing decay, the general structure of wood and causes of decay should be understood. Briefly then, wood is composed of a series of long, close tubes extending parallel to the long axis of the tree. These tubes, sometimes known as vessels and tracheids, are firmly united laterally and fitted together endwise in the form of a splice. Moisture or water is contained in the individual cells and intercellular spaces, as well as in the cell walls themselves. When first cut, a large amount of this water in the form of sap is present in the wood, which is said to be green. Later, as the moisture disappears by evaporation, the wood becomes seasoned, a purely relative condition depending upon the size of the timber, length of time seasoned, and atmospheric conditions. In general, however, structural timbers having a moisture content of from 15 to 25 per cent are considered well seasoned.

Contrary to a somewhat popular understanding, decay is not due to an internal disintegration of the wood fiber of its own accord, but is produced by the action of low forms of plant life which feed upon the wood cells and their contents and cause disintegration. These organisms are commonly known as "mycellia," these threads frequently form on the true action of the former, but for practical purposes it is probably similar to that of the fungi. This organism develops in the wood in the form of minute threads. Collectively known as "mycellia," these threads frequently form on the outside of the wood what is termed the "fruiting body," familiar examples of which are the toadstool-like growths so often seen upon railroad ties and other timbers affected with decay. From the "fruiting bodies" come the spores, which are blown about by the wind and attack the various forms of wood suitable for their development.

Necessary for the development of the fungi, however, are requisite amounts of air or oxygen, moisture, food, and heat. The complete elimination of any one of these factors will prevent decay. Illustrative of this is the long life of timbers completely buried in the ground or submerged under water, under which conditions there is an insufficient supply of air or oxygen for the development of the fungi. For most conditions, however, it is only feasible to destroy the food supply by impregnating the wood with materials poisonous to the fungi; it is on this theory that modern methods of timber preservation have developed.

Selection and Preparation of Material for Treatment.

The success of any preservative treatment depends very largely upon the proper selection of the material. First, it is essential that the species selected be adapted to impregnation; and secondly, it is preferable to treat those species not naturally resistant to decay. Fortunately these two conditions, poor decay-resisting properties and ease of impregnation, are closely allied. It is generally known that the heartwood of practically all woods is more naturally durable than the sapwood; so also is it more difficult to impregnate. Considering further, it develops that of the various species, the more naturally durable are also the more difficult to impregnate. For example: White oak and longleaf pine are durable timbers, containing relatively small amounts of sapwood. They are also of slow growth and corresponding high value. Experience has shown them difficult to impregnate satisfactorily. On the other hand, the quick-growing and non-durable loblolly and shortleaf pines, with their relatively large amounts of sapwood, can be readily and satisfactorily treated with a preservative.

Of equal importance to the selection of the material is its preparation. As previously pointed out, all wood contains more or less moisture. By one means or another, it is essential that much of this moisture be removed before the preservative can enter. In other words, the material must be seasoned. It is generally known that proper seasoning will greatly increase the strength of timber, but it is probably not so generally recognized that it is only after the evaporation of the free water from the intercellar spaces, corresponding to a moisture content of from 20 to 30 per cent for different woods and termed the "fiber saturation point," that the quantity of moisture will affect the strength. The curves in Fig. 1 show the effect of moisture upon the strength of longleaf pine, loblolly pine, chestnut and spruce timber.

*A paper read before the Engineers' Society of Western Pennsylvania.

Mr. Harry Donald Tiemann, who established this point several years ago, has more recently carried on investigations which indicate that at this same fiber saturation point, the internal cell walls of the wood minutely check and split, which would seem to explain the necessity for seasoning prior to impregnation. Also, this indicates the necessity of seasoning only to the fiber saturation point, since at this point the free water has been exhausted from the itnercellar spaces, and the cell walls themselves have split sufficinently to admit the passage of the preservative.

The first step in seasoning timbers is to remove the bark; unpeeled timbers can season only through the small areas of the exposed ends. The advantages of so doing are several. First, unless the bark is removed, seasoning will not satisfactorily advance. Secondly, preservatives can not be forced into bark. Unpeeled timbers, therefore, can not be successfully impregnated. Strange to say, this applies to the thin inner skin as well as to the main body of the bark. This is well illustrated in Fig. 2 which is a photograph of a section of a creosoted pine tie. The unpenetrated streak across the section was due to the presence of a small strip of the inner skin which adhered to the surface of the tie during the treatment.

Finally, peeling increases the natural life of the timber, and for this reason may be considered as the most simple method for preventing decay. It is estimated that by peeling alone, the durability of timber will often be increased as much as 50 per cent. Illustrative of this are the results of an inspection made by me of the timbers used in several coal mines in Illinois; of many peeled and unpeeled timbers, set under similar conditions and about the same date, extensive decay was found only in the latter; there was practically no decay of the barked timber.

Subsequent to peeling, there are several ways in which the timber may be seasoned. The most general and satisfactory method is to stack in piles and allow to air-season. The method of piling and duration of seasoning will, of course, depend upon the size, form, and species of timber, and the local weather conditions. Under all conditions, however, it is essential that the material be so piled as to admit the ready circulation of air and to provide for drainage of water. Fig. 3 shows a good method of piling ties to secure rapid seasoning and prevent incipient decay. Care must be exercised to prevent excessive checking of the material through too rapid seasoning. Figs. 4 and 5 show an exaggerated case of this checking, and a method for preventing it by the use of S irons. In the South, especially with such material as red and black oak ties, this trouble is of considerable importance, and the S irons or "stop-crack hooks" are extensively used at a cost of about one cent each, which includes placing them on the tie.

Other drawbacks to the air seasoning of timbers are the interest charges for from two to six months on an investment equal to the value of the material in question, and the tendency for incipient decay or dry rot to affect the timber. Commercial plants, especially in the South, often can not afford to air season their material on account of the loss due to the latter cause, and for this and other local conditions, recourse is frequently had to artificial methods such as steaming or boiling the material in the preservative prior to impregnation. With woods resistant to impregnation, such as the heart of longleaf pine, it is necessary that some such methods be used to secure a satisfactory penetration of the preservative. The experiments of Mr. Tieman, before referred to, indicate that steaming will cause checking of the cell walls of the wood similar to that caused by air seasoning. For general conditions, however, it is now the consensus of opinion that not only will the treatment of air-seasoned stock be more satisfactory than of green, but the actual cost will be less. Mr. F. J. Angier, timber engineer of the C., B. & Q., in a recent article presented before the New York Railroad Club, estimates this difference at about one cent per tie.

Preservatives.

The preservatives in general use may be divided into two main classes, oils and salts. Of the former, coal tar creosote or dead oil of coal tar is undoubtedly the most widely used and generally recognized as an efficient preservative. Produced as it is by the distillation of coal tar, its constituents are most complex, depending upon the character of the coal, temperature of coking, and temperature limits of the distillation of the tar. In general, however, the commerical product is the distillate coming over from the tar between a temperature range of from about 200 deg. to 350 deg. cent., and consisting of varying amounts of phenols, or tar acids, naphthalenes, and anthracenes, and their compounds. The merits of these various constituents are open to much discussion. Formerly, it was believed that the phenols or tar acids were the important factors, but an analysis of the oils extracted from creosoted timber after many years service show no such acids present, they doubtless having been lost through volatilization. So, also, naphthalene, which forms a very large part of the creosote manufactured in this country, is extremely volatile, and it is doubtful if, under general conditions, this will remain in the timber for a long period. It is, however, insoluble in water and is believed by many to be the most effective preservative in preventing the ravages of marine borers into piling. For most purposes though, the anthracene fractions are probably the most permanent and lasting in the wood, and creosotes containing relatively large percentages of these fractions are generally conisdered the more desirable. Unfortunately, since the production of creosote in this country is secondary to that of soft pitch, the distillation of the tar is not generally carried to sufficiently high temperatures to drive over a large percentage of the anthracene. In Europe, however, where the aniline dye industry is of prime consideration, the commercial creosotes contain a much larger percentage of authracene. As a rule, therefore, the foreign oils are of a superior grade to those produced in the United States. It is interesting to note that in 1909, 73 per cent of the creosote used in this country was imported.

There is another creosote produced from the tar resulting from the manufacture of illuminating gas from petroleum, which is very similar to the coal tar product. Generally known as oil-tar creosote or water-gas-tar creosote, it is used to some extent under its own name, but more frequently under the guise of coal-tar creosote. It is difficult clearly to differentiate between the two, the important difference being in the charatcer of the hydrocarbons forming their constituents. Whether or not a coal-tar creosote is any better as a preservative than one from an oil tar, has not yet been definitely settled. Many claim that the latter will prove equally efficient, and it is known that much of the product now sold under the name of coal-tar creosote consists largely of either oil tar or the creosote therefrom. On the other hand, the use of this material is too new for conclusive data as to its merits to have been secured, while there are many instances of extremely long service secured with timbers treated with coal-tar creosote. It is more than probable, therefore, that preference for this material will continue for some time to come. Appended to this paper are two specifications for coal-tar creosote; the first is that adopted by the American Railway Engineering and Maintenance of Way Association, and the second is one proposed for consideration by the Forest Service. A satisfactory grade of oil is doubtless covered by both specifications, but in the former no means for the detection of adulterations of petroleum products is given. Although the Forest Service method can not be said definitely to accomplish this under all conditions, it is yet believed that it covers a creosote consisting in the main of

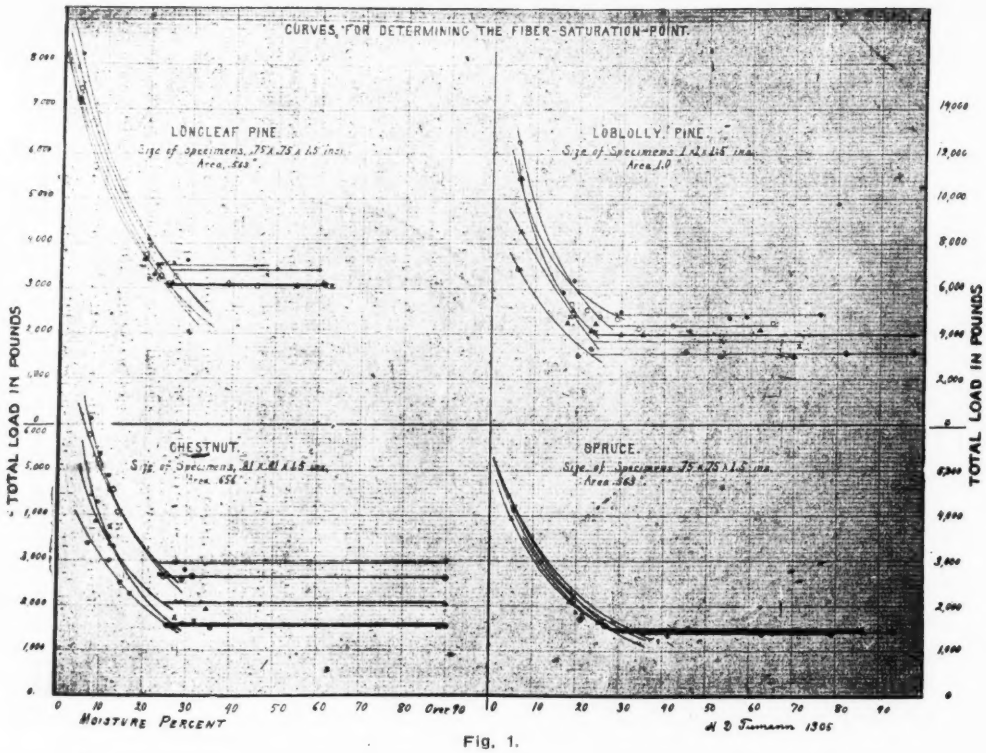


Fig. 1.

the aromatic hydrocarbons. It is probable that difficulty will at present be experienced in procuring an oil which will conform to this specification, but it would seem that if pure coal-tar creosote, by which is meant one from a tar from high temperature coking, is specified, that there should be some means of determining whether or not such a product is supplied.

Within the last few years the use of crude oils as wood preservatives has also developed to some extent. The success of such preservatives depends primarily upon so plugging the pores of the wood that the admission of sufficient air and moisture for the development of decay is prevented. The oils do not possess antiseptic properties, and for this reason their ultimate sucecss is still in question. The Santa Fe is experimenting on quite a large scale with such oil from Bakersfield, Cal., and a somewhat similar product known as "Ebano oil" which is procured from Mexico. Their experience seems to indicate that oils having an asphaltic base are of more value than those with a paraffin base. Pine and gum ties treated with the California product, laid in Texas in 1902, were inspected by me in September, 1909, and were found in excellent condition. The average life of untreated pine ties in this territory is only from 1½ to 3 years.

Wood creosote, or creosote produced from the distillation of wood tar, may also be mentioned in the class of oil preservatives. However, the production of this material

Fig. 2.

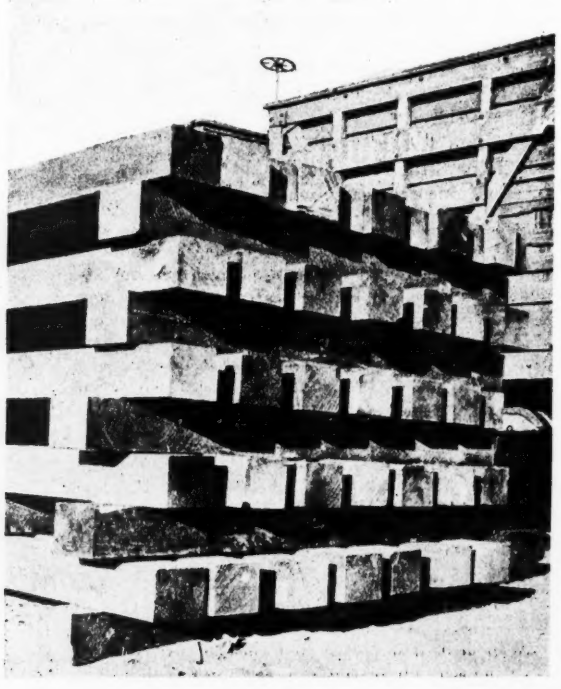


Fig. 3.

Fig. 4.

Fig. 5.

is so limited that it can not at present be considered of first importance in commercial treatments.

Referring now to the use of chemical salts: The success of such material in preserving timber depends primarily upon the antiseptic properties of the salt and its solubility in water, and secondarily upon a number of points, such as the effect upon iron and steel as used in the construction of treating plants, and the presence of acids or other chemicals which will cause disintegration of the wood. For such causes as the former, the use of copper sulphate and mercuric chloride, both excellent antiseptics, has been practically abandoned. Zinc chloride, however, has withstood the test of time, and is extensively used in this country. It is generally applied in the form of a 2½ to 4 per cent aqueous solution, the aim being to inject about ½ pound of the dry salt to the cubic foot of timber. As with all salt treatments, the chief objection is the subsequent leaching from the timber after treatment. Eventually this will reach such a point as to leave the wood insufficiently protected from the attack of fungi, when decay will set in. It is evident that such a

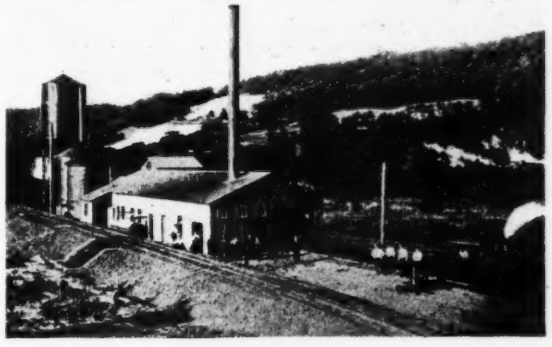


Fig. 12.

preservative is unsuited for timber to be used in damp and wet localities. It would never do for the preservation of piling. But when the material is to be placed in dry or arid regions, and when, aside from decay the mechanical life is limited, zinc chloride may be advantageously utilized.

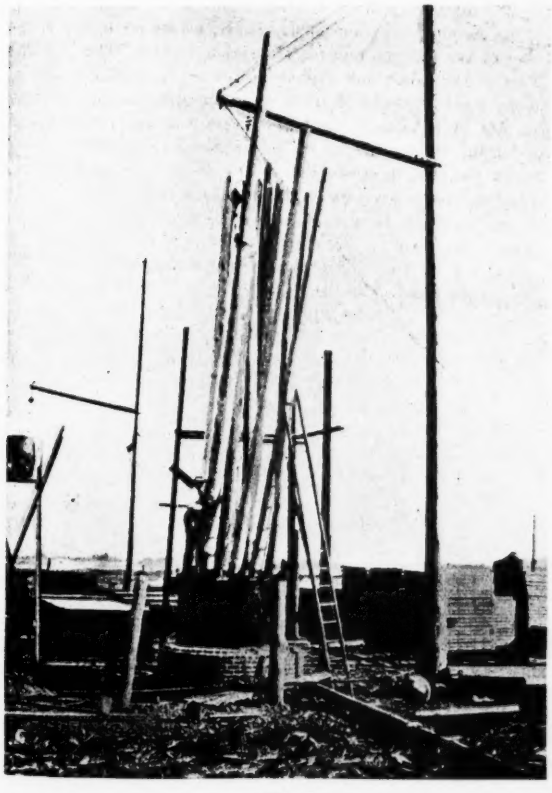


Fig. 6.

Fig. 8.

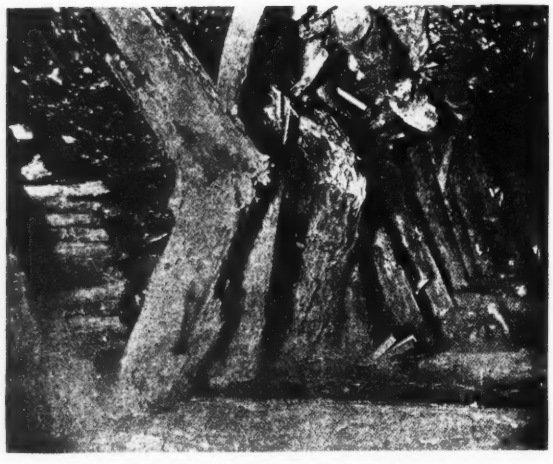


Fig. 9.

In comparing the relative merits of coal-tar creosote and zinc chloride, the cost of each must be considered. Creosote, although without doubt the most effective preservative at present in use, is also the most expensive. At a cost in bulk of from 8 cents to 10 cents a gallon, there is seldom used less than ½ gallon to the cubic foot of timber, and generally it falls nearer one gallon, frequently more than that. On the other hand, with zinc chloride, costing about 4 cents a pound, it is customary to inject not more than ½ pound per cubic foot, and frequently less. It is evident from this that for timber whose mechanical life is such that the full benefit of the creosote can not be obtained, the greater economy will accrue from the use of zinc chloride, either alone or in combination with a small amount of creosote. This latter method is frequently employed with ties, where the zinc chloride alone would not quite protect from decay throughout the mechanical life of the tie.

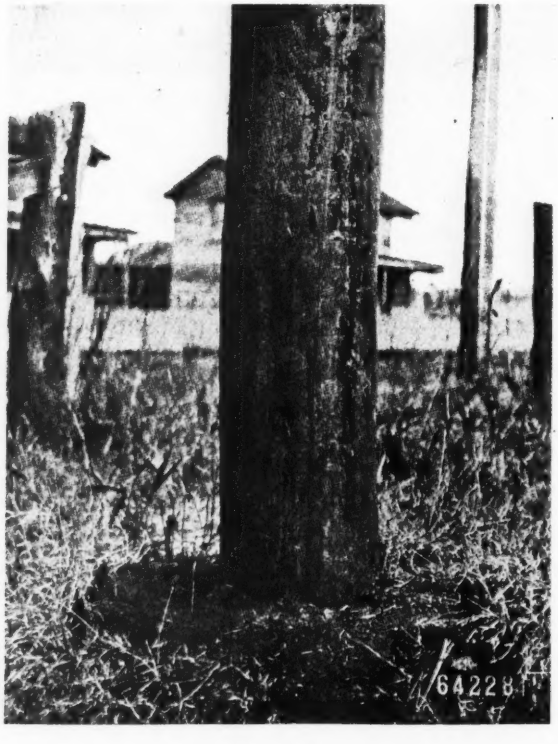


Fig. 10.

Processes.

In applying a preservative to timber, it is the prime object, first to secure a certain requisite absorption, and secondly, to distribute the preservative throughout the wood as uniformly as possible. There are a variety of methods for accomplishing these results, which may for convenience, be classified into brush, open tank and cylinder treatments.

The first of these, as the name implies, consists of applying the preservative with a brush, in other words, merely painting the material. It is the most simple and also the cheapest in first cost. Also, it is the least efficient of the methods. Only small absorption and slight penetration can be secured with this method, and it is applicable only with preservatives of the oil class. Such treatment, however, is better than none, and for general conditions will more than pay for itself if properly applied. It is suited for the butt treatment of poles, posts, etc., when the quantity of material to be treated is insufficient to warrant the installation of a plant. When used, the preservative is applied hot, and at least two coats, preferably three, should be given.

With the open-tank method, the material is submerged in

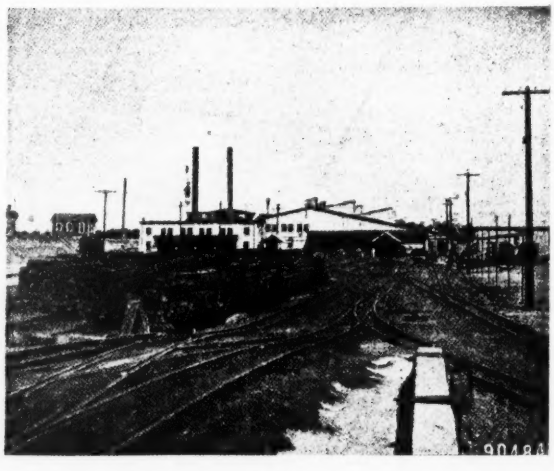


Fig. 7.

a tank containing the preservative and is there boiled for a period varying from one to five hours, according to the character of the material and the absorption desired. This has the effect of expanding and driving out of the intercellular spaces of the wood a portion of the air and moisture therein contained. After this heating, the charge is either allowed gradually to cool in the preservative, or the hot preservative is quickly transferred from the heating tank, which is at once refilled with relatively cool preservative. During this cooling, the remaining air and moisture in the wood contracts, forming a partial vacuum, which is in turn destroyed by the entering preservative. This method of treatment is simple, requiring but little and inexpensive equipment. When only a small quantity of material is to be treated, a small metal tank with fire underneath is all that is required. A more efficient plant will consist of a treating tank fitted with steam coils for heating, storage tanks for holding the supply of preservative, a receiving tank into which the preservative may be quickly emptied at the expiration of the heating period, a small pump, boiler, derrick, etc. A combination of creosote and zinc chloride may be used by heating the charge in the former and following by a cold bath in the latter. As with the brush treatment, this method is especially adapted for use with poles and posts. It is of distinct advantage in this connection, since the treatment of the entire pole is not desirable under most conditions. With loblolly pine and other woods having wide sapwood, very satisfactory penetrations may be

secured by the open-tank method. Its chief disadvantages are the expense of handling the material, the time required for a treatment, and the loss of preservative through volatilization during the heating period. High boiling creosotes are recommended for use with this process. Fig. 6 illustrates the open tank method of treating poles.

Although these two methods will serve the special purposes to which they are adapted, practically all commercial treatments of appreciable size are conducted under the cylinder class. The material is here loaded on small trucks which are run into horizontal cylindrical retorts fitted with track and steam coils. The doors on the ends of the retort are then bolted, the cylinder is filled with preservative from the storage or measuring tanks, and pressure sometimes as high as 200 lbs. per sq. in. is then applied to the charge with the force pumps. When the gauges on the measuring tanks indicate that sufficient preservative has been forced into the material the pressure is relieved, the cylinder is emptied and the charge is removed. Many of these plants with their full complement of retorts, tanks, pumps, boilers, cylinder cars, derricks, locomotive cranes, storage yard, fire protection, and necessary buildings, cost several hundred thousand dollars, and have an annual capacity of nearly 10,000,000 cubic feet.

On the other hand, serviceable plants for the smaller consumer with capacities varying from 300,000 to 500,000 cubic feet, have been installed for from $10,000 to $20,000. The size of the treating retort is customarily six or seven feet in diameter, with varying lengths up to 132 feet. The more recent plants are being built with seven-foot cylinders, which are evidently more efficient as to capacity than the smaller ones. Difficulty in handling the material off and on the cylinder cars apparently limits the practical diameter to seven feet. At the plant of the International Creosoting and Construction Co., at Texarkana, Tex., there is a retort 9½ feet in diameter by 160 feet long, but no other cylinder of such dimensions has ever been installed to the knowledge of the writer.

The details of treatment employed at the different plants are varied. The more important methods are in general as follows:

Full-cell Treatments: The object here is completely to fill the intercellular spaces with the preservative. If green timber is used, it is customary first to steam it in the retort by the admission of saturated steam at a pressure varying from 15 to 30 lbs. per sq. in. In some cases, as with heart longleaf pine, this is continued for as long as 24 hours. It is followed by drawing a vacuum of from 26 to 28 inches in the cylinder, which is maintained for several hours, or until no more moisture can be withdrawn from the charge. Without releasing this vacuum, the retort is then filled with the preservative and pressure applied until the requisite absorption is secured. If the material is well seasoned, the preliminary vacuum is omitted. When the zinc chloride is used, this method is known as "Burnettizing," and is the most suitable process for this preservative. With creosote, it is termed the "Bethell" process. From long experience it is known to be effective. Likewise, due to the large consumption of creosote, it is expensive. For use with piling, it is, however, admirably suited.

Empty-cell Treatments: In an attempt to reduce the high cost of the first method, while at the same time achieving its success, the empty-cell method has been developed. It is the purpose of such treatments merely to coat or paint the cell walls with creosote as thoroughly as possible. In other words, a maximum penetration with minimum absorption is desired. Typical of this treatment are the Rueping, Lowry, and "creo-air" processes. Fig. 7 shows a photograph of a plant using the Rueping process, and Fig. 8 of a plant using the Lowry process.

The theory of the Rueping process is first to subject the material to an air pressure of from 65 lbs. to 75 lbs. per sq. in. Without releasing this pressure, the cylinder is then filled with creosote, which is forced into the timbers with pressure varying from 100 lbs. to 175 lbs. per sq. in., according to the nature of the material. Pressure is then released, the creosote run off, and a vacuum applied to the charge. This release of pressure is said to permit the expansion of the compressed air forced into the timber during the preliminary stage, with a corresponding expulsion of the surplus or free oil. This method, first practiced in Europe, is now used extensively by the Santa Fe at its treating plant in Texas. With well-seasoned pine and gum ties, from five to seven hours are required for a treatment. In the Lowry process, as used by the American Creosoting Co., the preliminary air pressure is omitted, and recourse is had to the compression of the air in the wood by the entrance of the preservative during the pressure period, followed, of course, by the final vacuum.

Fig. 18.

The "creo-air" method, although aiming at the same results as the Rueping and Lowry methods, is operated upon a different theory. In this case only a limited quantity of the creosote is forced into the wood, after which the charge is subjected to a final air pressure. It is claimed by the advocates of this process that the effect of the final air pressure is to diffuse the creosote more thoroughly and completely throughout the wood.

Unfortunately, the development of the empty cell processes has only been within recent years. Their respective merits have not yet been conclusively determined. So far, timber so treated has given satisfactory results, but time only can definitely establish their merits.

Zinc-creosote Treatments: To overcome the leaching of zinc chloride from material treated with this salt, a treatment

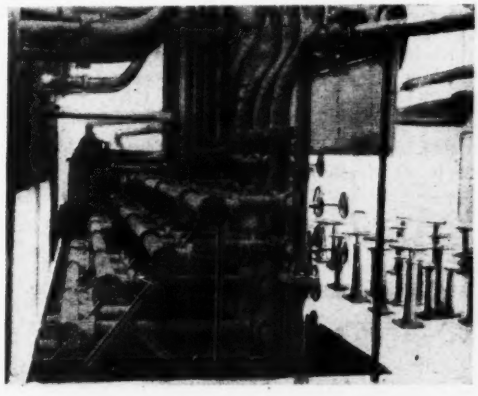


Fig. 19.

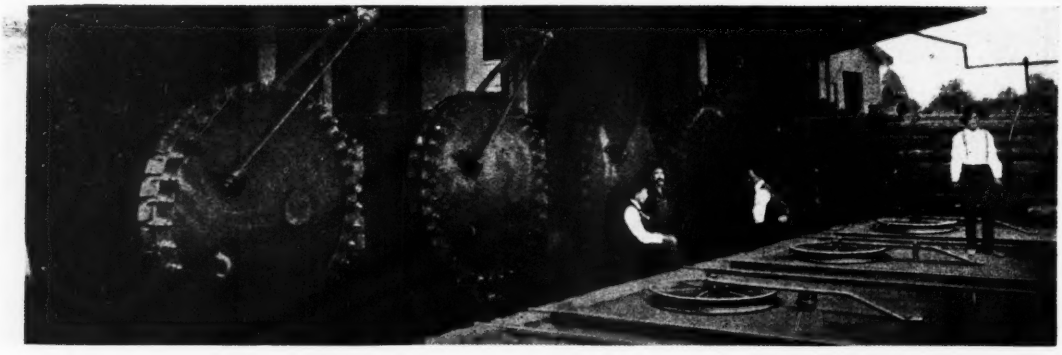


Fig. 17.

combining creosote with this chemical has been introduced. As practiced in the south, this is known as the "Allardyce" process. It consists in first treating by the regular "Burnettizing" method, after which the charge is impregnated with from two to three pounds of creosote per cubic foot. With red oak, which is fairly resistant to impregnation, it is customary to air season the material for from two to three months subsequent to Burnettizing. This is to rid the timber of the free water, and permit the ready entrance of creosote in the final impregnation. It is evident that a prime objection to such a method is its expense. More recently, Mr. Card has developed a process whereby the two preservatives are injected into the timber at one and the same time. In so combining these preservatives, the difficulty was to keep them in a proper and uniform emulsion, a difficulty due to the difference in the specific gravities of the two materials. Mr. Card has apparently overcome this by means of a centrifugal pump, the suction of which is attached to the top, and the discharge to the bottom of the treating retort. This is operated throughout the impregnating period, thereby keeping the preservatives well agitated and in emulsion. Timber treated by this process is used extensively by the C., B. & Q. and C., M. & St. P.

Boiling Method: This deserves mention, since it is representative of the practice on the Pacific coast. Here the charge is frequently treated green, and is first boiled in the creosote until the quantity of water given off from the cylinder, as determined by the discharge from a surface condenser, reaches a certain unit amount per hour. The heating is then discontinued, and the treatment progresses much as in the Bethell process. This treatment is somewhat similar in theory to that of the open-tank previously mentioned. The boiling period is primarily to season the material sufficiently to admit the preservative. As with steaming, care must be taken that the timber is not injured through excessive heating.

Economic Aspects.

The successful development of any preservative treatment, of course, depends fundamentally upon the ultimate financial saving. A decrease in the costs must ensue to justify its existence. This ultimate reduction in costs rests directly upon two prime factors, viz., the relative durability and the relative first costs of the treated and untreated material.

There is practically now no question as to the fact that the natural durability of timber is much increased by the proper application of a preservative. In Europe, Baltic pine ties, well creosoted and protected by tie plates and screw spikes from rail wear, give a service of over thirty years. Pine piling, creosoted about 1879, and set in the waters of the Gulf of Mexico, is still sound, while untreated similar material is destroyed by the teredo in from one to three years, and creosoted timbers set in some of the coal mines of Pennsylvania were in excellent state of preservation after 14 years, although similar untreated timbers, set under similar conditions, were replaced three times in that period on account of decay. For general figures of this nature, the Committee on Wood Preservation of the American Railway, Engineering and Maintenance of Way Association, in its report presented at the annual meeting in 1909, gives the life of piling, treated with from 16 to 24 lbs. of creosote per cubic foot, as 20 to 25 years; the life of properly creosoted ties, not protected from mechanical wear, as 15½ to 19 years; and the life of ties treated with from ¼ to ½ pound of dry zinc chloride per cubic foot, from 10 to 14 years. These are conservative figures, which will, of course, vary under different conditions.

The fact that more than 200,000,000 cubic feet of timber were used in the mines of this country in 1905, points to a wide field for the introduction of wood-preserving methods. In the coal mines of Pennsylvania, the conditions for the development of decay are almost ideal. There are many instances where untreated pine timbers have badly decayed within a year. Fig. 9 is a photograph taken in a coal mine showing decayed mine timbers.

Aside from the value of the timber, the cost of labor for replacement is a large expense, frequently equalling the cost of the timber. A preservative treatment of such timber need only increase its life for a comparatively short period, more than to pay for itself. Unfortunately, mining companies have only recently begun to realize the importance of wood preservation, and conclusive data as to the relative merits of the various preservatives for this purpose is lacking. However, experiments conducted by the Forest Service in co-operation with the Philadelphia & Reading Coal & Iron Co. show that the many preservatives used in the experiments have all increased the life beyond that of the untreated timber.

The photograph shown in Fig. 10 indicates the advantages of treatment applied to telegraph and telephone poles. In this case a creosoted pine pole near Norfolk, Va., was found in a perfect state of preservation after 18 years' service, while we know that similar material untreated will have a life of only 8 to 10 years.

As to costs, the initial expenditure for treated wood must of necessity exceed that for similar wood untreated. It is this which retards the development of wood preservation, but that the eventual cost will be less is yearly becoming more generally recognized.

Let us consider the assumed case of a railroad operating 100 miles of track, using red oak ties. Allowing 2,800 ties per mile, a five years' life for the untreated tie, 50 cents for its initial cost, and 15 cents for replacement, then the cost in track will amount to 65 cents per tie, or an annual expenditure of $36,400.00. If the tie is creosoted at a cost of 35 cents, the charge in place in the track will amount to one dollar. Assuming that five years will be required entirely to replace the untreated with treated ties, then the annual expenditure for renewals during that period would amount to $56,000.00. Allowing only fourteen years' life for the creosoted material, there would then be a cessation of renewals

for a period of nine years, when similar charges in a five-year period would again ensue. Allowing, therefore, 5 per cent interest on the investment in each case, and substituting in the standard formula, given below, the annual charge for the treated tie is found to be $0.101, and for the untreated $0.15. Economy would result if the treated tie gave only nine years' service.

This example only indicates the eventual saving which may be expected from wood preservation. The figures will, of course, vary for each and every problem or condition. If using the softer species, such as loblolly pine, tie plating is essential for the most efficient results. Such a tie properly treated and protected from mechanical wear, will far outlast the more naturally durable white oak. It is also cheaper, and the difference in cost of the two may well be expended in a preservative treatment of the inferior species. Finally, the supply of such durable timbers as white oak is diminishing, and recourse must sooner or later be had to the more plentiful and quick-growing woods. As a rule, these are well adapted to treatment. Fig. 11 is a graphic representation of the average life of untreated ties in Texas, compiled from the records of tie removals in the experimental track of the Gulf, Colorado & Santa Fe.

There remains one final factor affecting the economic aspects of wood preservation, which is the always increasing price of timbers. How great this increase will be is impossible to predict, but that it will continue is undisputed. In comparing the ultimate costs of treated and untreated timbers, we must, therefore, remember that the initial cost of timber necessary for replacements five or ten years from now will be much greater than at present, and every additional year of service which may be secured by the application of a preservative at the present time, will cause a financial saving equal to the difference between the present and the future cost of the untreated product.

Coal-Tar Creosote Specifications.

Specification for a Coal-Tar Creosote as Adopted by the American Railway Engineering Maintenance of Way Association*

The oil used shall be the best obtainable grade of coal-tar creosote; that is, it must be a pure product of coal-tar distillation, and must be free from admixture of oils, other tars or substances foreign to pure coal-tar; it must be completely liquid at thirty-eight (38) degrees centigrade, and must be free from suspended matter; the specific gravity of the oil at thirty-eight (38) degrees Centigrade must be at least 1.03. When distilled according to the standard method; that is, using an eight (8) ounce retort, asbestos covered, with standard thermometer, bulb one-half (½) inch above the surface of the oil, the creosote, calculated on the basis of the dry oil, shall give no distillate below two hundred (200) degrees centigrade, not more than five (5) per cent below two hundred and ten (210) degrees centigrade, not more than twenty-five (25) per cent below two hundred and thirty-five (235) degrees centigrade, and the residue above three hundrd and fifty-five (355) degrees centigrade, if it exceeds five (5) per cent in quantity, must be soft. The oil shall not contain more than three (3) per cent water.

Specification for Grade A Creosote Proposed by the Forest Service.†

The creosote should be derived from the distillation of pure coal tar and free from any adulteration whatever or any mixture of undistilled tar. If it contains more than 3 per cent by weight of water a deduction in price corresponding to the per cent of water in excess of that amount will be made. It shall have a specific gravity at 60 degrees centigrade of not less than 1.04. When analyzed by the standard Forest Service method of analysis for coal-tar creosote, it shall have the following fractions calculated on a moisture free basis*:

(a) Up to 205 deg. cent. not more than 5 per cent.

(b) Up to 235 deg. cent. not more than 40 per cent, nor less than 5 per cent.

(c) Up to 250 deg. cent. not more than 50 per cent, nor less than 15 per cent.

(d) Up to 295 deg. cent. not more than 65 per cent, nor less than 30 per cent.

(e) At 355 deg. cent. the residue must be soft and not sticky.

On applying the sulphonation test to the fraction between 305 deg. cent. and 320 deg. cent. there chall be no oil residue insoluble in caustic alkalies.

The indices of refraction at 60 deg. cent. shall be as follows for the following fractions:

$$A = p\,\frac{(1+R)^m R}{(1+R)^m - 1}$$

A = annual charge
p = initial investment
m = number of years in recurring period
R = rate of interest, expressed decimally

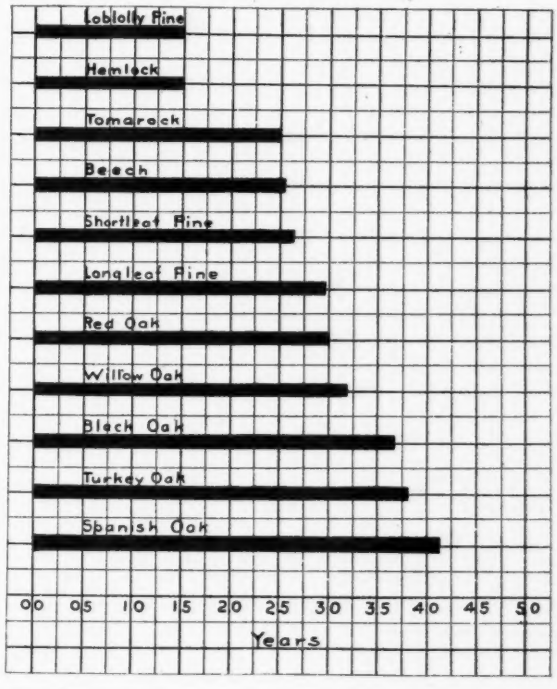


Fig. 11.

(a) At 250 deg. cent. not less than 1.593 nor more than 1.602.

(b) At 290 deg. cent. not less than 1.615 nor more than 1.622.

(c) At 300 deg. cent. not less than 1.625 nor more than 1.632.

(To be continued.)

A. R. Fugina, formerly assistant signal engineer of the Chicago & Northwestern, has been appointed signal engineer of the Louisville & Nashville, with office at Louisville, Ky., succeeding C. J. Cannon, resigned.

*When less than 3 per cent of water is present in the creosote it shall be considered moisture free.

†A revision of these specifications is now under advisement.

The Maintenance of Way Department

Killing Weeds.

Editor "Railway Engineering":

I have never used any chemicals for the purpose of destroying or killing weeds on the right-of-way. I find that in this country, to get the best results in destroying and killing weeds, you should mow them between June 25th and July 10th. There are species of weeds which require cutting a second time; this should be done before the weeds go to seed. I find that if the work is properly done in this manner that it will have the effect of destroying the growth to a large extent, and in the course of time stop their growth almost entirely.

Ontario. ROADMASTER.

Editor "Railway Engineering":

This company requires that during the grass growing season, only so much grass and weeds must be removed as is absolutely necessary to keep the rails clear. At the end of that season the grass must be cut accurately to sod lines and the roadbed kept clean until the beginning of the next growing season. On many railways, where inferior ballast is used, and the section gangs are small, the weeding and cleaning to lines is very annoying and expensive. This is particularly the case in tropical and semi-tropical countries, where vegetation is heavy, and in prairie countries, where track must be kept clean to prevent fire. On parts of one transcontinental road the total cost is $30.00 to $35.00 per mile per year, and on dirt track in semi-tropical countries $50.00 to $60.00 per mile per year. I usually endeavor to supply our men with long-handled shovels for this purpose. These again come handy for ditching. The spreading of common salt, one barrel to 500 or 800 feet, has been found satisfactory. A weed killing machine on another large road had an electric generating plant supplying current to a brush of copper wires suspended across the track, and while the work was satisfactory, the cost was prohibitive for general work. Spraying with a strong solution of hot brine will be found satisfactory excepting damage to rails by corrosion. The rails could, however, be protected by guards. A heavy application of oil also checks the growth. A method has been used on a railway in Ecuador, where the heavy vegetation required 1,600 gallons per mile sprayed by steam or compressed air from a car run at a speed of 4 or 5 miles per hour. In this case precautions had to be taken against poisoning, the solution being composed as follows: 1 lb. arsenical acid to 5 gallons hot water, 1 lb. nitrate to 6 gallons, of water.

The solutions are made separately in tanks having capacities in ratio 5 to 6, and then mixed in a third tank. The method of burning weeds is followed by many roads. It costs about $5.50 per mile.

California. ROADMASTER.

Winter.

Editor "Railway Engineering":

I consider the most important work to be done by section forces in preparation for winter is cleaning out ditches, cleaning from around switches and frogs, putting track in good surface and alignment, before it freezes, and to see that all switches, frogs, and guard rails, are in perfect condition.

Michigan. GENERAL ROADMASTER.

Switch Stands.

Editor "Railway Engineering":

Whenever possible switch stands should be placed on the closed side of the switch, or with the switch rod pulling toward the stock rail instead of pushing, as would be the case if placed on the open side. The same should apply to all locking devices in connection with hand or mechanically thrown switches. The reason is obvious. If a switch is thrown to its normal position there is always a possibility of some foreign substance getting between the point and the stock rail, and the switch rod or switch bar bending and presenting a partially open switch. While if the switch is pulled to its normal position and locked, no such condition can arise without being detected.

The color of targets differ widely on different roads, but where two position targets are used, a round target is used for clear and an oblong square or diamond shape for turnout. Targets should be enameled whichever color is used and are washed clean with every rain storm or can be washed or wiped off by lamp lighters.

New York. SUPERVISOR OF TRACK.

Editor "Railway Engineering":

It is our practice to use a switch stand on the closed side of switch points. In my opinion the most effective form and color of switch stand target is red for danger, and green for clear. On all single track we use practically all high semaphore switch signals, which stand about 16 feet high, with an arm on the right hand side of the post, when facing. Arm is painted red with a white stripe painted across, about 6 inches, from the end. Stop is indicated on switches thrown for side by a square end semaphore arm displayed in a horizontal position. Proceed is indicated for showing a clear track at this switch by the arm lowered at least one-half way to the post, and with a green light when switch is set for siding.

Illinois. SUPERVISOR.

Editor "Railway Engineering":

We place all switch stands, when possible, on the engineman's side of the track. We have had collisions caused by their being on the opposite side and do not consider that they should be placed there unless it is impossible to put them elsewhere. We use for main line, a single blade target, painted red, which shows nothing when switch is set for main line, but shows a red banner across track when set for side track or cross-over. On side tracks we use a black banner with a yellow circle painted in the middle.

Massachusetts. ROADMASTER.

Editor "Railway Engineering":

As far as possible, where side tracks and yards do not interfere, our practice is to place the switch stand on the closed side of the switch, so as to let the rod pull the switch points closed instead of pushing them closed when set to the main line. We consider this the better practice.

I believe that the single target is the best form and that the round disc about 16 inches in diameter for the intermediate and high target stand is the best signal. The reason I like the single target stand is that unless the switch is open, or partially so, there is nothing visible to the engineman and there can be no misunderstanding or claim on his part or that of the train crew, that the signal was rusty and they could not distinguish the color of the target.

South Carolina. ROADMASTER.

Editor "Railway Engineering":

I cannot see any objection to switch stands being placed on either side. It is the custom, where room will permit, on main tracks to place switch stand on the right hand side of the track in the direction facing the switch, to give the engineman better view in approaching switch in head-on direction.

The color which seems to be the best for main line is green and red, while for sidings red and yellow. They are distinct colors and do not conflict with other lights in the vicinity of the switches.

New York. DIVISION ENGINEER.

Editor "Railway Engineering":

Switch stands should be placed and maintained on the closed point side. In this position the switch stand is more liable to be on the engineman's side, and less liable to breakage in the connections when a switch stand is so placed on a closed point side. If the stand was placed on the open point side, it is readily to be seen that the entire length of the connection would be in service, and on the entire length of the connection would depend the efficiency of keeping the closed point securely in place.

Ontario. ROADMASTER.

Editor "Railway Engineering":

Switch stands should be placed on the closed side of switch, or in other words, on the turnout side. The most effective form and color for switch stand target is no target for the main line and an eighteen inch red target for the siding, to indicate that when there is no target shown, the switch is clear for the main line, and when the red target is shown, to indicate that the switch is set for the siding.

Michigan. GENERAL ROADMASTER.

Editor "Railway Engineering":

I consider the proper place for switch stand to be on the closed side of the switch. If it is inconvenient to place it on the closed side, a car lock should be installed for more protection. I also consider red the most effective color for targets.

Iowa. ROADMASTER.

Construction

The Porterville, Northeastern has awarded a contract for the construction of about 16 miles of road between Porterville and Springville, Tulare county, California, to the Utah Construction Co., Ogden, 520 Phelan building, San Francisco.

The Esquimalt & Nanaimo has awarded a contract to Janse, McDowell & Co., Port Alberni, British Columbia, for work from Cameron Lake on the island of Vancouver, to Port Alberni, a distance of 28 miles, also from Duncans to Cowichan Lake, 18 miles.

The Canadian Northern has awarded contracts to Eslick & Hartnett, Spokane, Washington, for 52 miles of rock construction, to cost $250,000. The Canadian Northern has also awarded a contract to the Northern Construction Co., Winnipeg, Manitoba, for the construction of the first sixty miles of its line from Vancouver to Chilliwac, British Columbia, and for the seventy-nine-mile stretch between Chiliwac and Hope, British Columbia. Arrangements are being completed for the construction of the road on Vancouver Island. The main line will run from Victoria to Alberni, via Sooke.

The Colorado Southern has awarded the contract to Kilpatrick & Terrell, Denver, Colorado, for the construction of the 35-mile extension between Wellington and Cheyenne. Work will be started immediately, and will cost when completed $1,500,000. Contract covers grading and all bridge work up to rails and ties.

The Queen & Crescent Route has awarded a contract for second track from Oakdale to Lancing, Tenn., at an estimated cost of $200,000.

The Nueces River Railway has begun construction on the line west of Beeville and has made application for an amendment to the charter to cover a line from Beeville to Aransas Pass. The intention to have both lines under construction for the entire line, which is 307 miles long, has been let to Robert W. Lyle & Co., Chicago, Ill.

The Florida East Coast Railway Co., has awarded contract to the Kissimee Valley Construction Co., to extend its line from Maytown to some point of Lake Okeechobee, 130 miles.

The Kansas & Southeastern has awarded a contract to the St. Louis Construction Co., Pratt, Kansas, for the construction of its line. The road will run from Almena, Kansas, in the northern part of the state to Anthony.

The Wabash has work underway on 30 miles of double-tracking from Delray to Adrian, Michigan. Wm. Carmichael Co., 1218 Fullerton building, St. Louis, has the general contract.

The Allegheny & Northwestern has awarded a contract to John Schaffner for grading 6.5 miles of line between Evans City, Pa., and Mars. The plans call for a line from Evans City to Harmarville, a distance of 21 miles.

The Colorado & Southern has awarded a contract to Kilpatrick Brothers, of Omaha, Neb., for the construction of a new line between Cheyenne and Wellington, Colo., a distance of about 28 miles.

A mechanical interlocking plant will be installed to protect the crossing of the Missouri, Kansas & Texas, the St. Louis Southwestern, and the Trinity & Brazos Valley at Hillsboro, Texas. This plant will have 32 levers.

The Erie is building telephone booths of concrete at sidings and other places along its line where telephone sets have been installed for the use of trainmen in connection with installations of telephone train dispatching apparatus.

It has been officially announced in Boise, Idaho, that the Harriman system, operating in the southern part of the state, will during 1911 construct a new main line east and west across the state, to be known as the Owinza-Payette or Boise cutoff, passing through Boise and placing in operation a new railroad 220 miles in length. Besides the construction of this road, the Oregon Short Line will build a number of short feeders covering territory that is now isolated from transportation facilities.

Press reports say that the Florida East Coast has let to a Delaware corporation a contract for the construction of 135 miles of new lines to cost more than $1,500,000. The new road will extend from Maytown to Whittier, and thence to Lake Okeechobee in the Everglades, with a branch line to Fort Bassinger on the Kissimmee River.

The Boston Revere Beach & Lynn will change its gage to standard and extend its line northerly. A tunnel is also to be built between East Boston and South Boston, and there is a movement on foot to build a freight tunnel between the North and South stations.

The material for the lift bridge that is to be built in the center of the reinforced concrete causeway which is being constructed across Galveston Bay to connect the mainland with Galveston is arriving on the ground. Rapid progress is being made by the A. M. Blodgett Construction company in erecting the arches for the causeway. The structure will be 10,642 feet long. The reinforcing metal has been placed in all the piers and a number of the arches. The causeway is now more than two-thirds finished, and it is expected that it will be ready for use the latter part of March or early in April. It will cost $1,500,000.

Work has been commenced clearing the right of way for the branch of the Detroit & Mackinac which will run from

Posen to Rogers City, and operations will be pushed all winter. The Michigan Limestone & Chemical Co., which is doing the preliminary work on an immense stone crushing plant at Calcite, just outside of Rogers City, must have the railroad to bring in several steam shovels and other heavy machinery for use early in the spring.

The Nickel Plate is building double track culverts between Chicago and Fort Wayne preparatory to double tracking its line.

The El Dorado & Western, which operates about 10 miles of road from El Dorado, Ark., to Wesson, is building a twenty-mile extension southwest from Wesson. The Edgar Lumber Co. has the contract. This line will be extended to Shreveport, La., 82 miles from Wesson, in the near future.

The Alberta & Great Waterways has awarded contracts for building the line to Foley, Welch & Stewart, St. Paul, Minn., and work will be started at once. The line will run from Edmonton to Fort McMurray, 362 miles.

The Seaboard Air Line has awarded a contract to E. L. Anderson & Co., Dummellon, Fla., and work is now under way on an extension from Fruitville, northwest to Venice, 18 miles. Kibler, Boswell & Co., Dummellon, Fla., have also been awarded a contract for work from Hernando to Inverness, 5 miles.

The Florida Railway is building an extension from Live Oak east to Jacksonville, 82 miles, and from Jacksonville north to Fernandina, 29 miles. The Florida Realty & Construction Co., Jacksonville, Fla., are the contractors. Surveys are also being made for an extension of 50 miles from Perry to Tallahassee.

The Missouri Pacific has awarded a contract to the L. J. Smith Construction Co. to rebuild the Kansas, Nebraska & Dakota.

The Erie has awarded a contract for grading a second track, six miles long, from Braceville to Windham, Ohio, and second track, five miles long, from Nankin to Ashland, Ohio, to the Ferguson-Edmondson Co., Brook Valley, Pa.

The Lehigh Valley has awarded a contract for double-tracking 6.2 miles, from Laurel Junction to Silver Brook Junction, Pa., to Walter H. Gahagan, 189 Montague street, Brooklyn.

The San Diego, El Paso & St. Louis has been organized to build 525 miles of road from El Paso, Texas, east, via Artesia, N. M., to the Red River in Texas, and has awarded the general contract to the McCarthy Engineering Corporation, Houston, Texas. The work will include some heavy earth and bridge work and six tunnels aggregating 2.75 miles.

Track laying has begun on the new double-track railroad being built jointly by the Denver & Rio Grande and the Colorado & Southern between Pueblo and Walsenburg. The grading forces moved an average of 40,000 cubic yards of earth a day during the past month. The entire line will be finished by September. The construction will cost in the neighborhood of $4,000,000.

The provincial government of Ontario will build a branch of the Temiskaming & Northern Ontario railway from a point on the line near Kelso to Porcupine. The distance will be 30 or 32 miles and the cost about $450,000.

Fast Railroad Construction.

The last of the transcontinental trails—the St. Paul Railway—represents the fastest building time ever known in the railway world, says F. A. Miller in Leslie's. The first shovel of earth was turned on April 2, 1906. The last rail was laid near Missoula, Mont., on March 29, 1909. The extension of more than 1,400 miles, the outlet of a great railway system to the Pacific Coast, was built in less than three years. During this period more than 60,000,000 cubic yards of material had been excavated, 360,000 yards of tunnel driven, twenty miles of bridge erected and over 200,000 tons of eighty-five pound rails laid. The total cost of building this extension was nearly $100,000,000. On some days more than five miles of new railroad a day, over all sorts of country, were built. In early times a mile a day was considered almost a miracle under the most favorable conditions. But this line was built in sections and seems almost to rise from the ground simultaneously throughout its whole extent across the continent. From St. Paul, Minn., the old line had been previously built to Aberdeen, S. D. The line was finished to Marmarth, 288 miles west of Aberdeen, October 10, 1907, and to Terry, Mont., 371 miles west of Aberdeen, February 16, 1908. It reached Miles City March 1, 1908, and Lombard, Mont., 722 miles west of Aberdeen, March 15. From Harlowtown to Lombard, Mont., the line of the Montana Railroad, already constructed, was used, and the opening of train service to Lombard, on March 15, 1908, gave through service to Moore, Mont., and Lewistown, Mont. The city of Butte was reached in May, 1908, and the last rail laid near Missoula, Mont., on March 29, 1909.

Imperial Valley Irrigation.

Mexico has given her consent for the construction by the United States of a levee in Mexican territory to control the waters of the Colorado river for the protection of Imperial valley, Cal. Congress at its last session appropriated $1,000,000 for this purpose, but it was necessary to procure the sanction of Mexico because the work will be done in that country.

Eucalyptus Obliqua Ties.

A shipment of 70,000 railway ties of "stringy bark" (Eucalyptus obliqua), sometimes termed Tasmanian oak, left Hobart for the United States in October. Two similar shipments will follow, making a total of 210,000 sleepers of Tasmanian timber for the United States. Stringy bark is much in demand for railway sleepers, being nearly everlasting. Some forest tramways in use by Tasmanian sawmills were laid with stringy-bark sleepers more than fifty years ago, and they are still perfectly sound. The average life of these sleepers resting on gravel ballast and subjected to a rainfall varying between 20 and 60 inches per annum is about fifteen years. The wood is practically non-inflammable, and this is especially suitable for underground railways. It is comparatively immune from the ravages of white ants and other land insects, and also is especially suitable for harbor construction, being very dense and immune from the attacks of marine insects. A sample of the wood was recently taken from a Hobart pier after being under water for thirty to forty years, and it was perfectly sound.—*Consular Reports.*

Section Laborer and Personal Injuries in Mississippi.

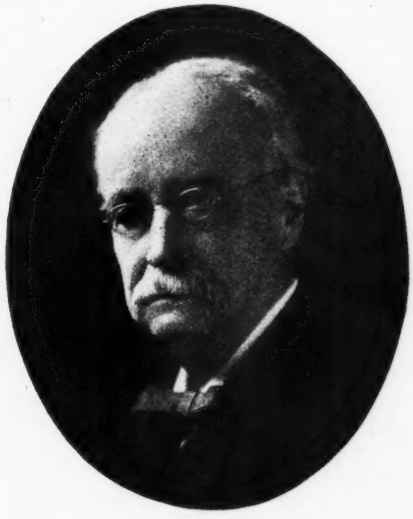
On the theory that a section laborer is "within the general line of hazard inherent in the railway business," although not engaged in the actual operation of trains, the Supreme Court of the United States has upheld the constitutionality of the Mississippi law abrogating the fellow servant rule as to "every employee of a railroad corporation." It has been claimed that a section laborer could not be held to be engaged in a hazardous occupation, and therefore that the law was unconstitutional. The point arose in the case of Ray Hicks of Newton county, Mississippi. Judgment of $7,500 in favor of his heirs was awarded in the Mississippi courts against the Mobile, Jackson & Kansas City. The suit was then appealed to the Supreme Court.

J. A. Cook has been appointed supervisor of terminals of the Wabash at Kansas City, Mo.

E. B. Gallagher has been appointed assistant general signal foreman of the Illinois Central at Chicago.

R. G. Kenly.

R. G. Kenly has been appointed chief engineer of the Minneapolis & St. Louis and the Iowa Central, with office at Minneapolis, Minn. He succeeds W. D. Taylor, whose jurisdiction has been withdrawn from these lines.



D. J. Whitmore.

Don Juan Whittemore, chief engineer of the Chicago, Milwaukee & St. Paul, and of the Chicago, Milwaukee & Puget Sound lines east of Butte, with office at Chicago, having been with the St. Paul and its predecessors continuously for 57 years, has resigned from that office and has been appointed consulting engineer, an honorary position created in recognition of the high character and unusual length of his service. Mr. Whittemore was born at Milton, Vt., in 1830. He was educated at the Bakersfield Academy, Vt., and began railway work in 1847 with an engineering corps on the Vermont & Canada, now part of the Central Vermont. Two years later he was appointed assistant to the chief engineer in charge of construction between Swanton, Vt., and Rouses Point, N. Y., and then went with the Great Western of Canada, where he remained until 1852. He was also for a time with the Central Ohio when that road was being built from Zanesville, Ohio, to Wheeling, W. Va. He was made assistant to the chief engineer of the La Crosse & Milwaukee, now part of the Chicago, Milwaukee & St. Paul, in 1853, and for three years from 1860 was chief assistant to the chief engineer. From 1857 to 1859 he was also chief engineer and director of the Southern Minnesota (land grant) Railroad, and for two years from 1858 chief assistant engineer on the Ferrocarril Del Oeste in Cuba. When the La Crosse & Milwaukee was merged with the Chicago, Milwaukee & St. Paul in 1863, he was appointed chief engineer, which position he held continuously until his resignation on December 6. Since March, 1906, he has been chief engineer also of the Chicago, Milwaukee & Puget Sound. He is a member of the American Society of Mechanical Engineers and of the Institution of Civil Engineers of Great Britain. He received the degree of Doctor of Laws from the University of Wisconsin and of Civil Engineering from the University of Vermont.

SHOP EXTENSION, CHICAGO & NORTHWESTERN.

The Chicago & North-Western has for several months past been building an addition to its Chicago shops to take care of the rapidly increasing repair work due to the increase in the number of locomotives now operated. The road owns 1,580 engines, a few of which are narrow gauge.

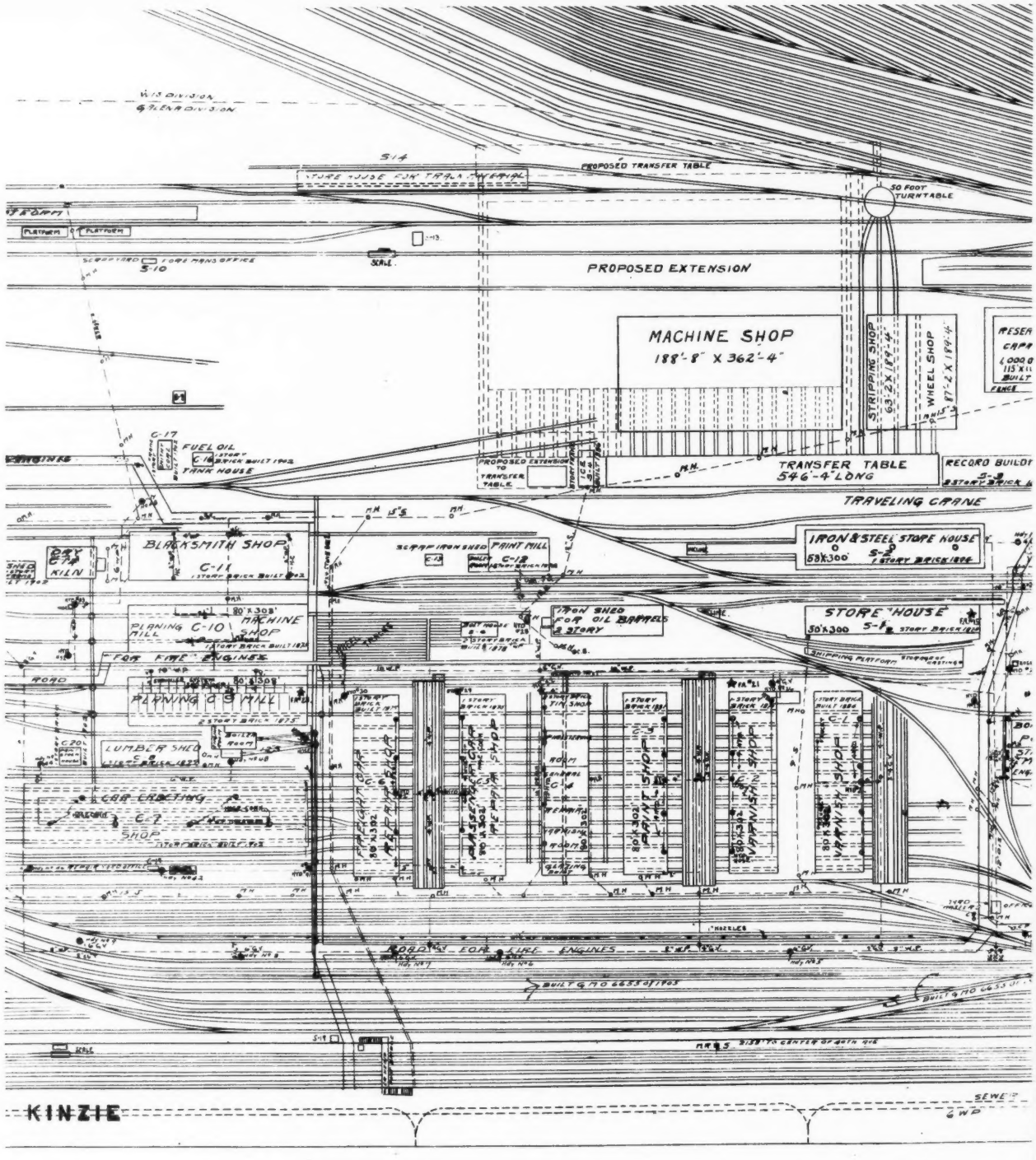
The present machine and erecting shop was laid out and built in 1873 and 1874. Since then no addition to the erecting shop proper has been made, as it was possible up to the present to handle the comparatively enormous increase in motive power repair work in the old shop. This fact is a unique testimonial to the foresight of the original designers. The only mistake in the layout was the failure to allow for a comprehensive extension of the facilities. A two-story annex to the machine shop was built in 1899, extending to the west of or at right angles to the old erecting shop. This was for the accommodation of the modern large machine tools which could not be placed in the old shop.

Referring to the drawing of the shop layout, it will be seen that the addition, now nearly completed, consists of an erecting shop, a wheel shop and a stripping shop. Owing to the position of the yards it was not possible, as first intended, to place the new erecting shop parallel to the old shop in a north and south direction. It was therefore laid down at right angles with provision for indefinite extension to the west.

The erecting shop measures 188 ft. 8 ins. by 362 ft. 4 ins. and is fitted with fifteen pits reached by a transfer table, with a track 546 ft. long to the south of the building. Provision has been made for an extension of ten pits to the west and for a duplicate of the building paralleling it on the north, as shown on the drawing.

What seems to be a serious inconvenience in taking locomotives to the transfer table from the roundhouses will be noticed by a study of the drawing. With the original north and south plan it would have been possible to run locomotives directly onto the transfer table and thence to the erecting shop pits. As the shop has been built it will be necessary to place them on a turntable to the north, thence over a track through the stripping shop, where the engines are completely stripped, thence on shop trucks to the transfer table and then to the erecting shop pits. Adjoining the stripping shop to the east is a wheel shop fitted with a ten-ton crane. In this shop are the large wheel presses and lathes.

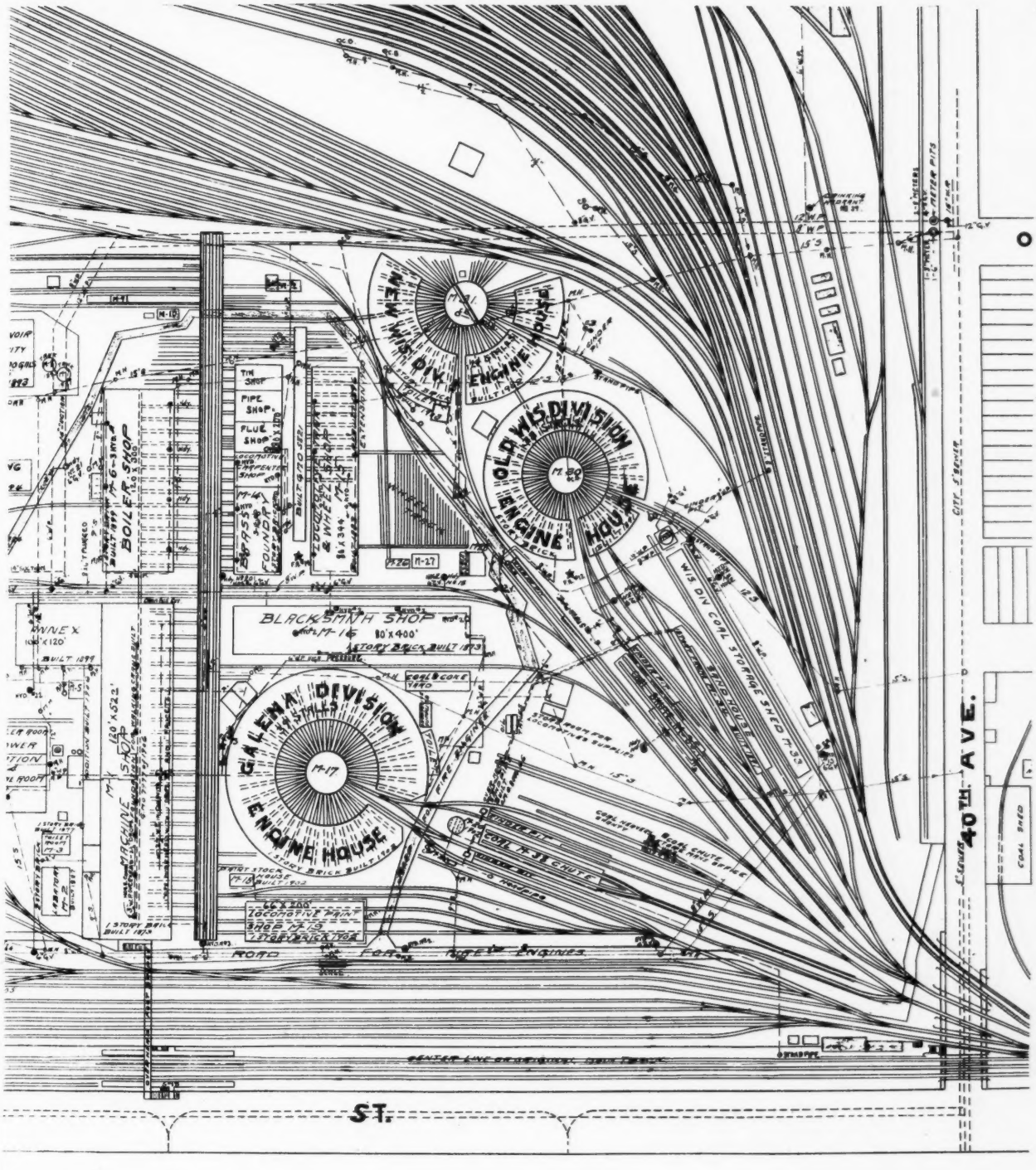
One of the interesting features is the transfer table which is 50 ft. long and is designed to handle Mallet locomotives weighing 200 tons without tender. The working speeds are 250 ft. per minute, with heaviest load, and 600 ft. without load. The engine haul is designed to pull locomotives on or off the table at a speed of 275 feet per minute. All of these



C. & N.-W. Shops.

speeds may be reduced a little over one-half by running the motors in series. The cable is carried on four rails in the pit, the drive being through a single shaft on one side of the table. This table was made by Geo. P. Nichols & Bro., Chicago.

The turntable, over which all engines to be shopped must be taken, as shown on the drawing is of the same length and capacity as the transfer table. It is operated by a heavy duty electric tractor capable of turning the heaviest engines a full revolution in not to exceed one minute, balanced or out of balance. In addition an electric hauling device is provided to pull locomoties on or off the table at a speed



C. & N.-W. Shops.

of from 50 to 100 feet per minute. The control of both the turning and hauling appliances is from the operator's cab mounted on the tractor. This tractor and hauling apparatus was also built by Geo. P. Nichols & Bro., Chicago.

To H. T. Bentley, assistant superintendent of motive power and machinery, and to his superior, Robert Quayle, is due most of the credit for the preliminary designing of the extension. J. C. Little, mechanical engineer, has creditably performed that section of the work which would naturally fall to his share. The structural design was performed in the engineering department under E. C. Carter, chief engineer, with the assistance of outside architects.

The Signal Department

Railway Signal Standards No. 14.—The Santa Fe

All automatic block signals on the Santa Fe system stand normally clear. The latest signals are of the upper quadrant, three-position, semaphore type, but there are in service a number of lower quadrant, two-position semaphores and some enclosed disks. Semaphore blades are 4 ft. 6 ins. long and are red for home signals, Figs. 326, 327. Night color indications are red for stop, yellow for caution, green for clear. Semaphore signals are operated by electric motors, either at the base or top of post. To these current is supplied by caustic soda battery housed in wooden or concrete wells, wooden or concrete boxes, Figs. 328, 329, 330, 331, or in iron cases at base of signal. Disk signals are operated by gravity battery, housed as above. The same type of battery is used for signal operation and line circuits, but the same battery is not common to both. Track circuits, usually one-half mile long, are supplied from gravity battery, usually three cells in parallel, housed either in the well with the other cells, or in a chute of iron or concrete, Fig. 329.

Various combinations of signal foundations, battery boxes, cable posts, etc., are used, Figs 331, 332, 333, 334. Iron foundations are also used, Figs. 335, 336. Fig. 337 shows the arrangement of apparatus at a signal location.

Wires from the line are taken to a cable post of wood, Fig. 338, or concrete, Fig. 339, to which is attached a lightning arrester box, Figs 340, 341, 351. Often the concrete cable post foundation is combined with that of the signal, as explained above, as is also the relay box post. Fig. 342 shows a wooden battery box. Fig. 343 is an anchor bolt.

Number boards are used to designate the signals, Fig. 344. A preliminary section board appears in Fig. 349.

Wire ducts consist of wooden trunking and capping run below ground. Figs 345, 346, 347 show the sizes used and methods of making joints, corners, bootlegs, etc. Fig. 348 shows the bootleg and connections to rail. Manganese rails are bonded as shown in Fig. 350, by means of steel plugs.

Figs. 352, 353 show how gage and switch rods are insulated. Fig. 354 shows the type of point lugs used for connections to switch points.

Circuits for sticking on indicator, used in slotting power operated signals, are shown in Fig. 355. Figs 356, 357 show how power operated distant signals are controlled at block stations.

Overlaps are used only on single track. Switch indicators of the same type as the signals in their territory are used. Also, three-position polarized indicators are used on double track. Track relays are of four ohms resistance and conform to the R. S. A. specifications.

A separate pole line for signal wires is not used. A common return wire is not used.

The following sizes and classes of wire are standard: For line, No. 9, B. & S. gage galvanized iron; for bootlegs, No. 8, B. & S. gage galvanized iron; for leads from track and in chutes, No. 9, B. & S. gage rubber covered copper; for leads from line and from battery, No. 14, B. & S. gage, rubber covered copper.

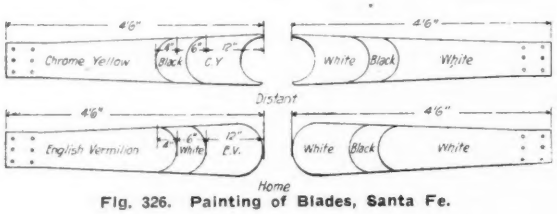


Fig. 326. Painting of Blades, Santa Fe.

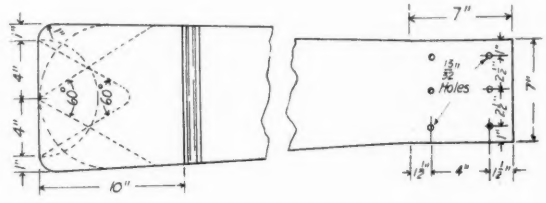


Fig. 327. Dimensions of Blades, Santa Fe.

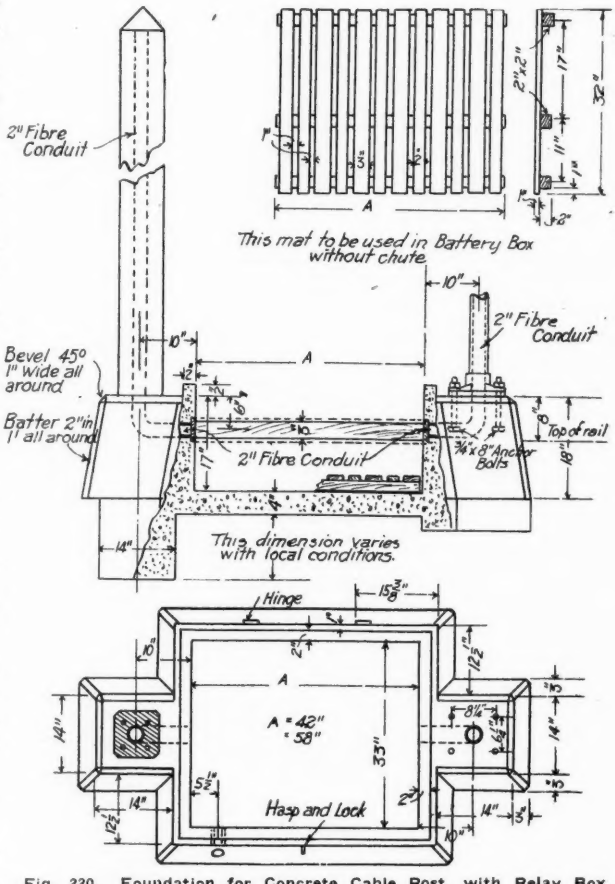

2" Fibre Conduit
This mat to be used in Battery Box without chute
Bevel 45° 1" wide all around
Batter 2" in 1' all around
2" Fibre Conduit
Top of rail
3/4"x8" Anchor Bolts
This dimension varies with local conditions.
Hinge
A = 42" = 58"
Hasp and Lock

Fig. 330. Foundation for Concrete Cable Post, with Relay Box Post, and Concrete Battery Box Combined, Santa Fe.

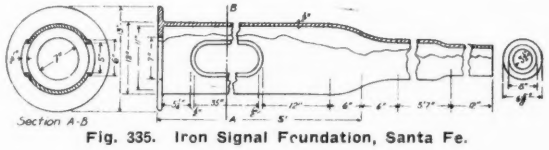


Fig. 335. Iron Signal Foundation, Santa Fe.

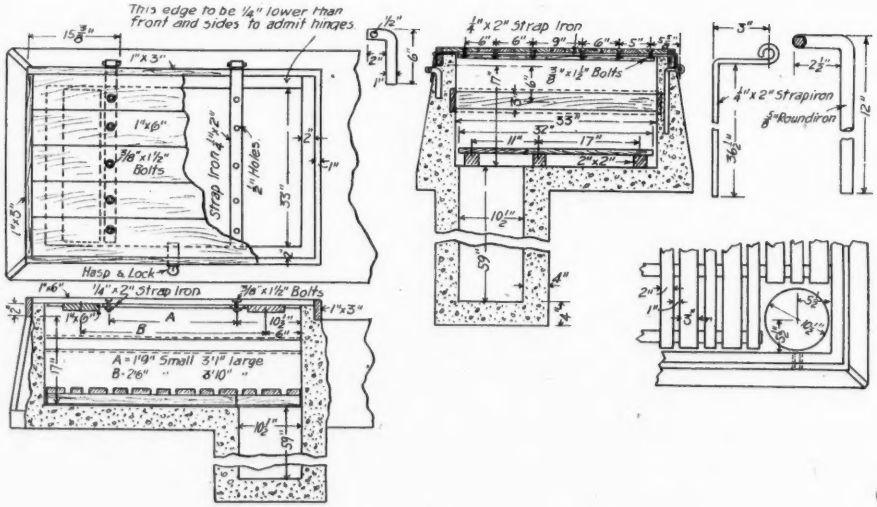


Fig. 329. Concrete Battery Box and Chute, Santa Fe.

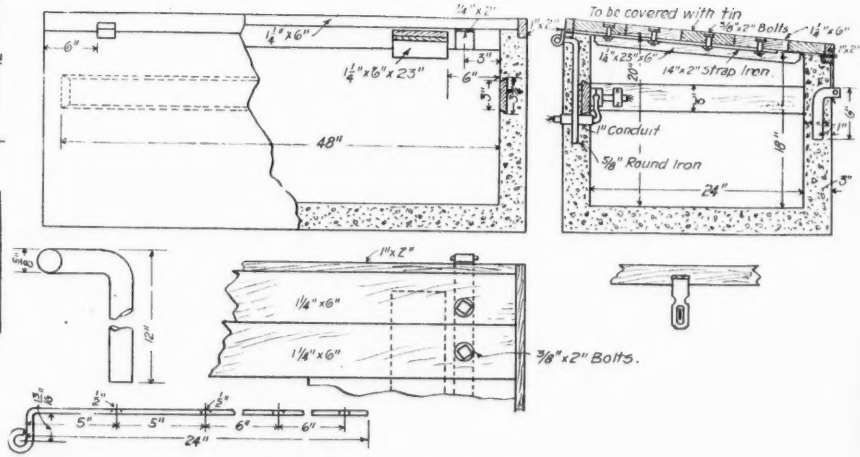


Fig. 328. Concrete Battery Box, Santa Fe.

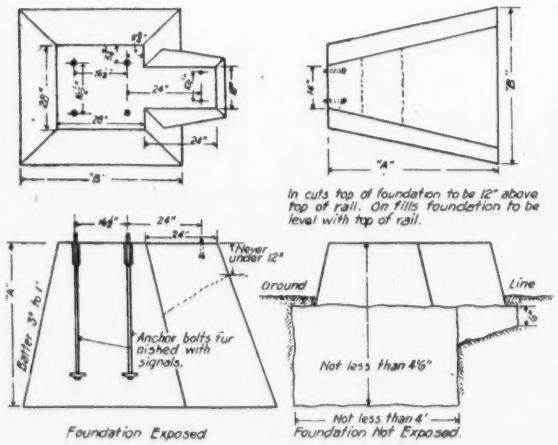

"B"
"A"
Concrete to be made of -
1 Part Portland Cement
3 " Clean Sand
4 " Crushed Rock
In cuts top of foundation to be 12" above top of rail. On fills foundation to be level with top of rail.
Where foundation is not exposed a pit 4' square is to be dug and filled to within 6" of the ground line from thereup foundation to be carried in form and with batter of 3" per ft. Footing for ladder, as shown on plan, to start 12" below ground line.
Form not to be taken off under two days.
When form is removed all exposed parts of foundation to be whitewashed with equal parts cement and screened sand, to be applied with old brush or broom. When first coat dries apply a second.
"A" This dimension will be governed by local conditions but all foundations to be carried to solid footing.
"B" To be 28" plus 6" for every 12" of dimension "A".
Never under 12"
Ground Line
Anchor bolts furnished with signals.
Batter 3" to 1'
Not less than 4'6"
Not less than 4'
Foundation Exposed
Foundation Not Exposed.

Fig. 332. Foundation for Top Post Signal, Santa Fe.

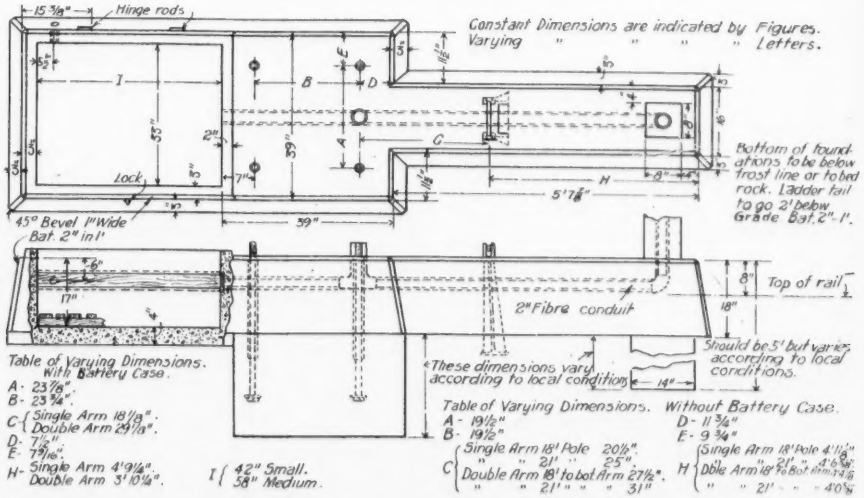

15 3/8"
Hinge rods
Constant Dimensions are indicated by Figures.
Varying " " " " Letters.
Lock
45° Bevel 1" Wide
Bat. 2" in 1'
39"
5'7 1/8"
Bottom of foundations to be below frost line or to bed rock. Ladder rail to go 2' below Grade Bat. 2"-1'.
2" Fibre conduit
Top of rail
Should be 5' but varies according to local conditions.
These dimensions vary according to local conditions
14"
Table of Varying Dimensions. With Battery Case.
A- 23 7/8".
B- 23 3/4".
C- Single Arm 18 1/8". Double Arm 29 1/8".
D- 7 1/2".
E- 7 9/16".
H- Single Arm 4'9 1/4". Double Arm 3'10 1/4".
I 42" Small. 58" Medium.
Table of Varying Dimensions. Without Battery Case.
A- 19 1/2"
B- 19 1/2"
D- 11 3/4"
E- 9 3/4"
C- Single Arm 18' Pole 20 1/2". " " 21' " 25". Double Arm 18' to bot Arm 27 1/2". " " 21' " " 31"
H- Single Arm 18' Pole 4'1 1/8". Dble Arm 18' to Bot Arm 4'6 3/8". " " 21' " " 4'10 5/8"

Fig. 331. Combination Signal Foundation, Battery Box and Cable Post, Santa Fe.

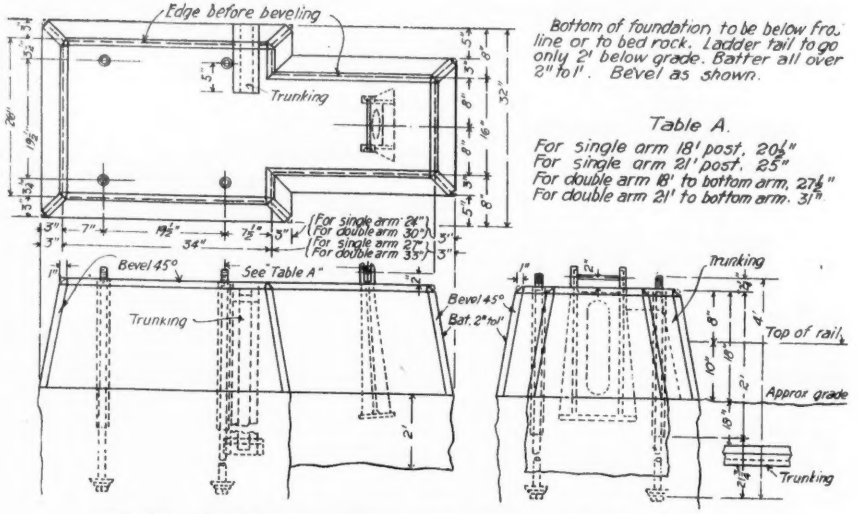

Edge before beveling
Trunking
Bottom of foundation to be below frost line or to bed rock. Ladder tail to go only 2' below grade. Batter all over 2" to 1'. Bevel as shown.
Table A.
For single arm 18' post, 20½"
For single arm 21' post, 25"
For double arm 18' to bottom arm, 27½"
For double arm 21' to bottom arm, 31"
(For single arm 24" / For double arm 30" / For single arm 27" / For double arm 33")
Bevel 45°
See Table A"
Bevel 45°
Bat. 2" to 1'
Trunking
Top of rail
Approx grade
Trunking

Fig. 334. Foundation for Bottom Post Signal with Battery Case, Santa Fe.

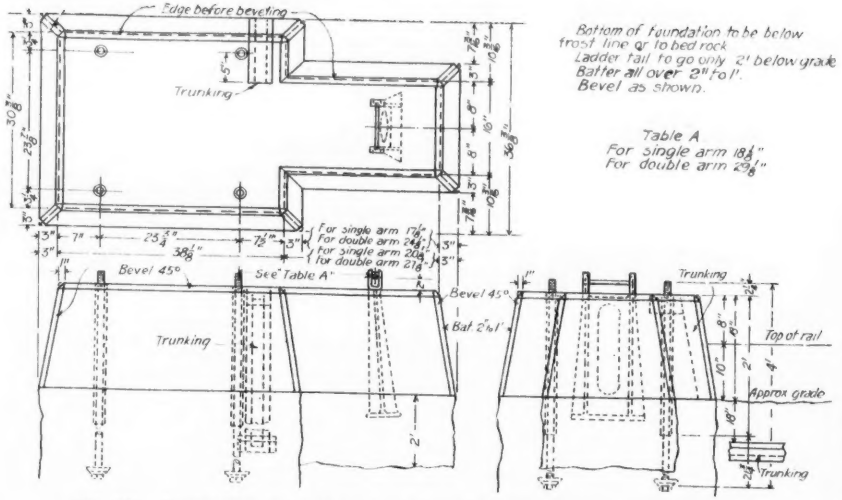

Edge before beveling
Trunking
Bottom of foundation to be below frost line or to bed rock. Ladder tail to go only 2' below grade. Batter all over 2" to 1'. Bevel as shown.
Table A
For single arm 18½"
For double arm 29⅛"
(For single arm 17⅛" / For double arm 24⅝" / For single arm 20⅛" / For double arm 27⅛")
Bevel 45°
See Table A"
Bevel 45°
Bat. 2" to 1'
Trunking
Trunking
Top of rail
Approx grade
Trunking

Fig. 333. Foundation for Bottom Post Signal without Battery Case, Santa Fe.

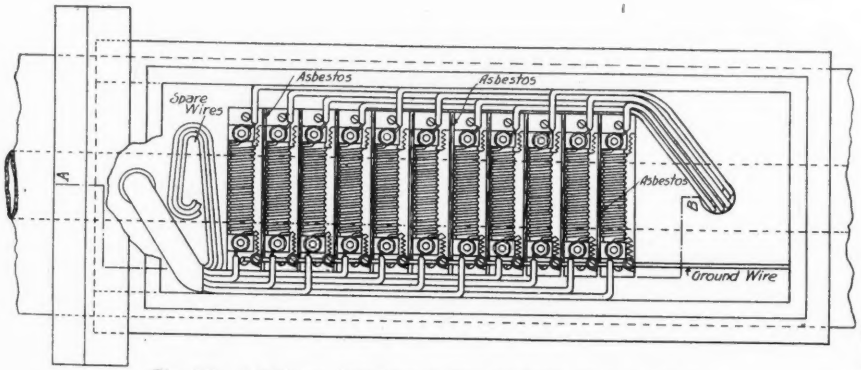


Fig. 340. Lightning Arresters in Box on Cable Post, Santa Fe.

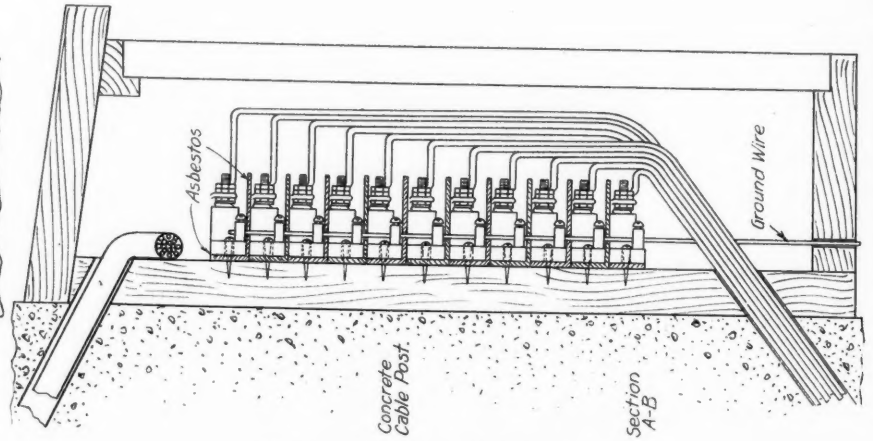


Fig. 341. Same as Fig. 340, Santa Fe.

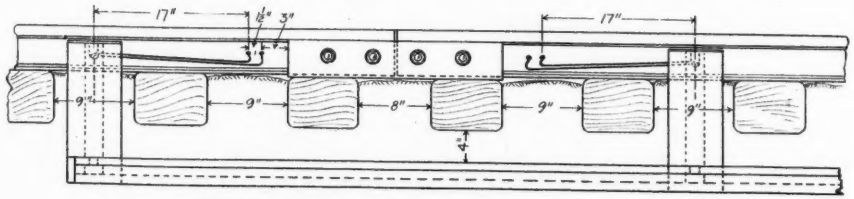


Fig. 348. Bootleg and Connections to Rail, Santa Fe.

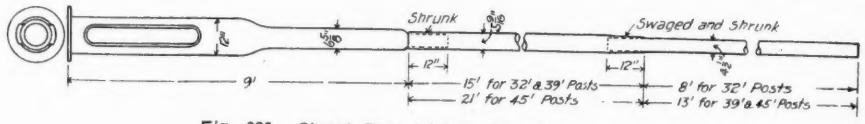


Fig. 336. Signal Post in Iron Foundation, Santa Fe.

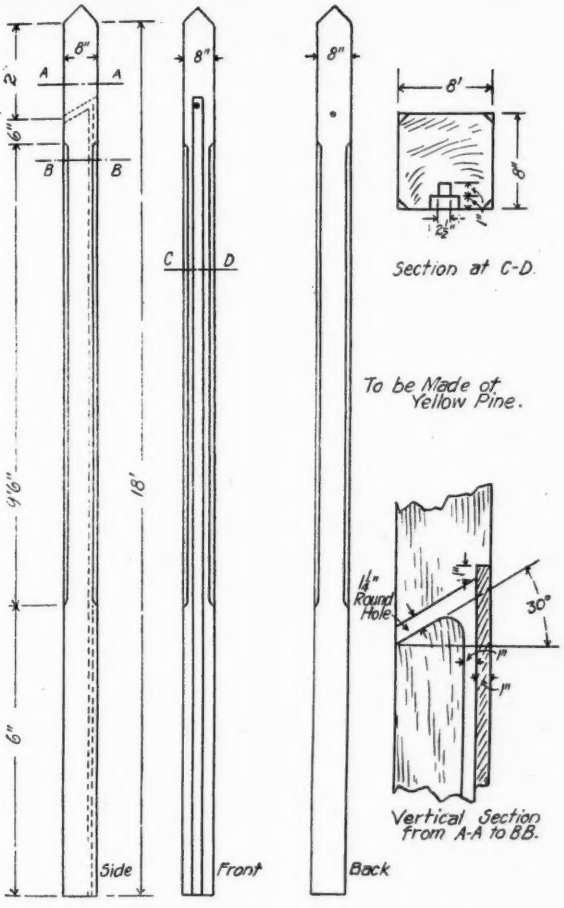


Fig. 338. Wooden Cable Post, Santa Fe.

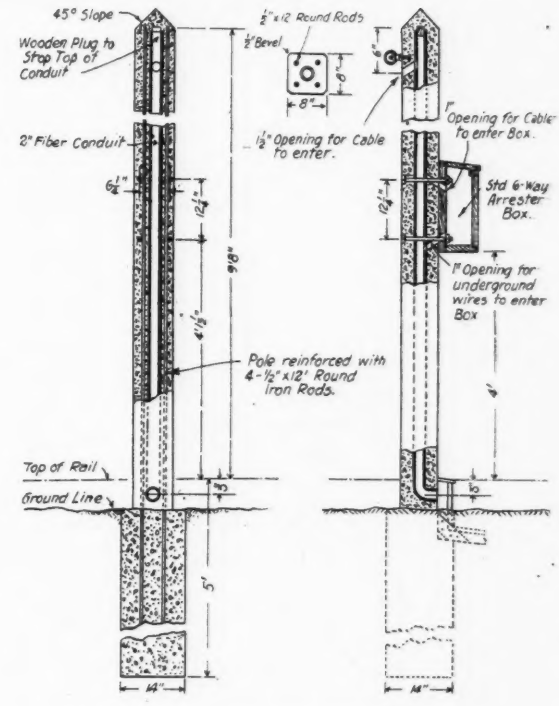


Fig. 339. Concrete Cable Post, Santa Fe.

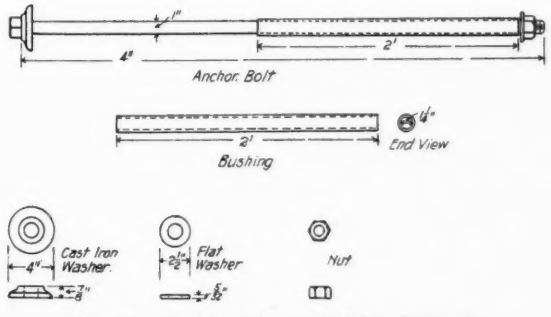


Fig. 343. Anchor Bolt and Details, Santa Fe.

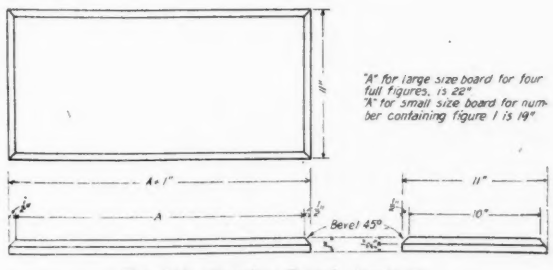


Fig. 344. Number Board, Santa Fe.

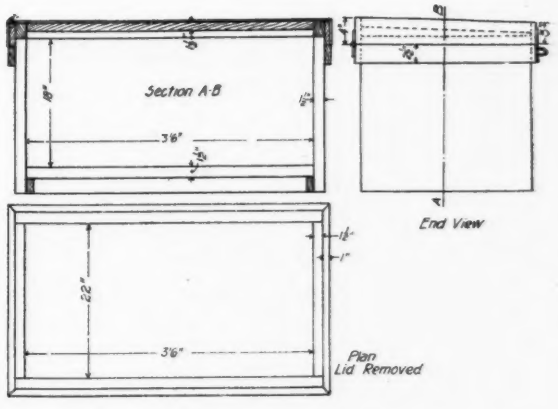


Fig. 342. Wooden Battery Box, Santa Fe.

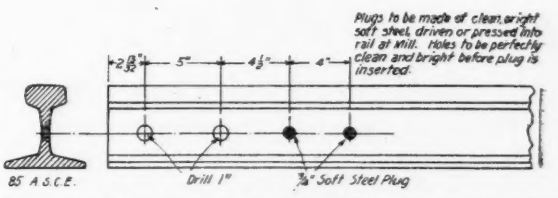

Plugs to be made of clean, bright soft steel, driven or pressed into rail at Mill. Holes to be perfectly clean and bright before plug is inserted.
2 13/32"
5"
4⅝"
4"
85 A.S.C.E.
Drill 1"
⅞" Soft Steel Plug

Fig. 350. Method of Bonding Manganese Rail with Soft Steel Plugs, Santa Fe.

Fig. 348. Bootleg and Connections to Rail, Santa Fe.

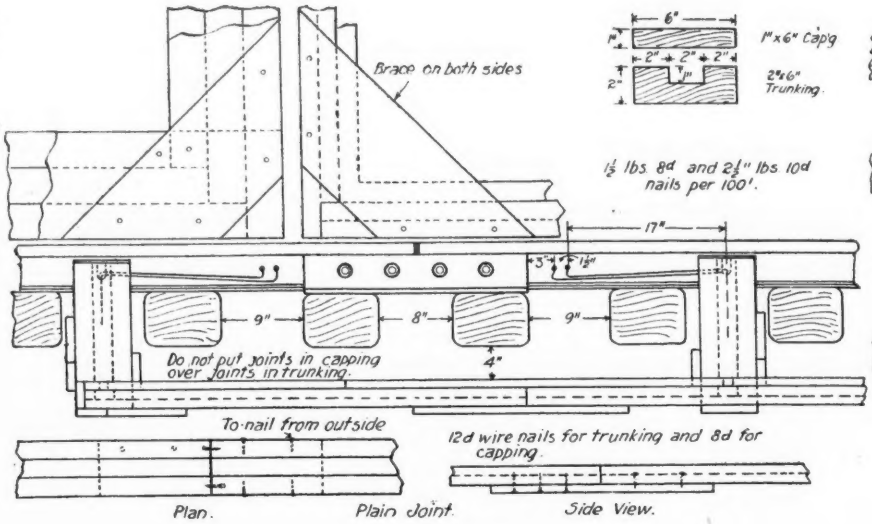


Fig. 345. Trunking Joints and Bootleg, Santa Fe.

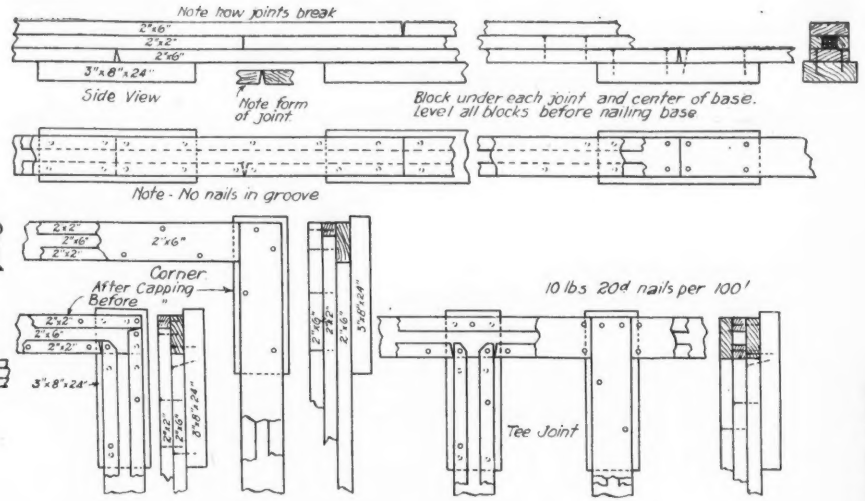


Fig. 346. Trunking Corners and "T" Joints, Santa Fe.

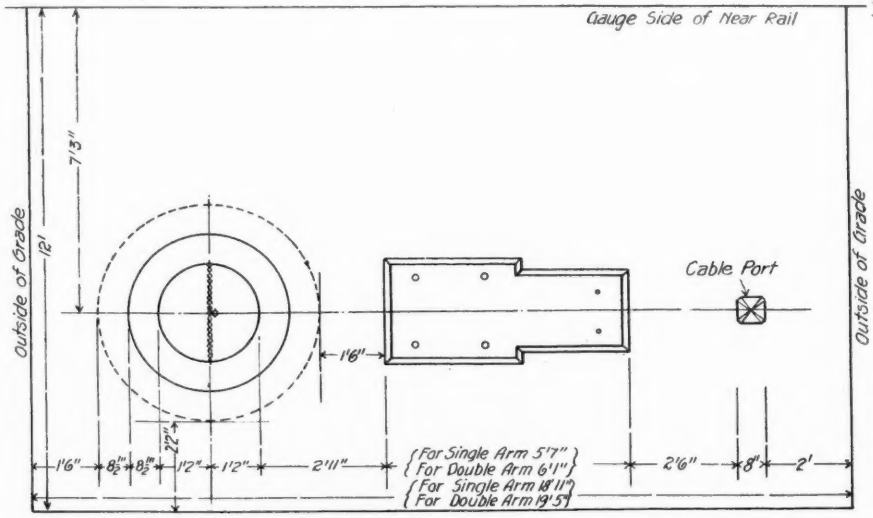
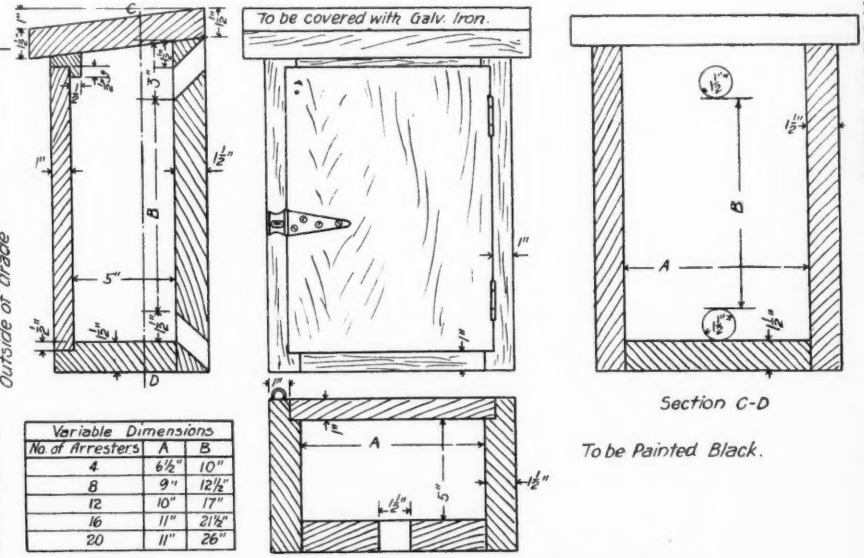


Fig. 337. Layout of Signal Foundation, Cable Post and Battery Well, Santa Fe.



Variable Dimensions		
No. of Arresters	A	B
4	6½"	10"
8	9"	12½"
12	10"	17"
16	11"	21½"
20	11"	26"

Fig. 351. Wooden Lightning Arrester Box, Santa Fe.

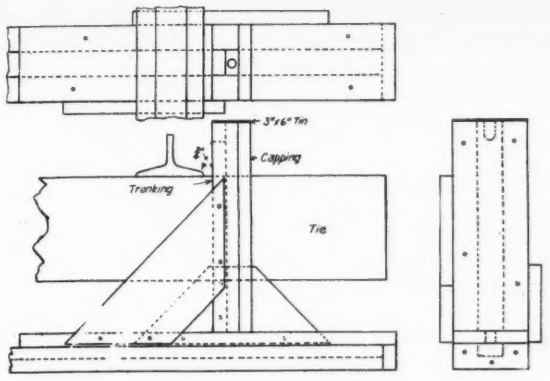


Fig. 347. Bootleg, Santa Fe.

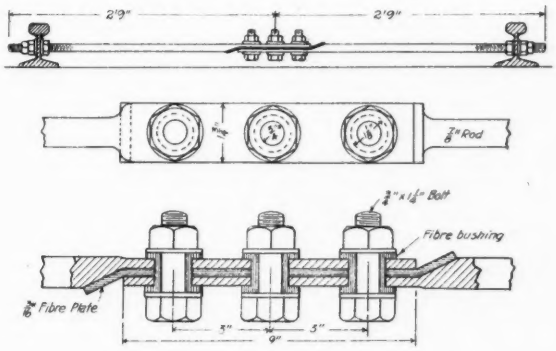


Fig. 352. Insulated Gage Rod, Santa Fe.

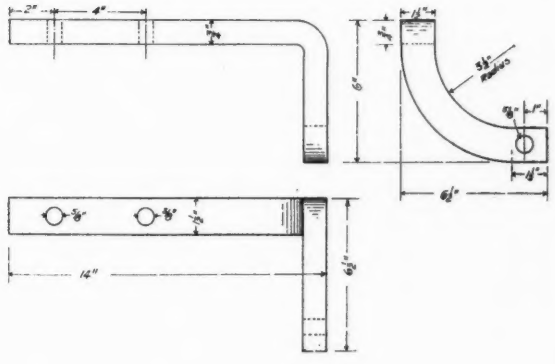


Fig. 354. Point Lug, Santa Fe.

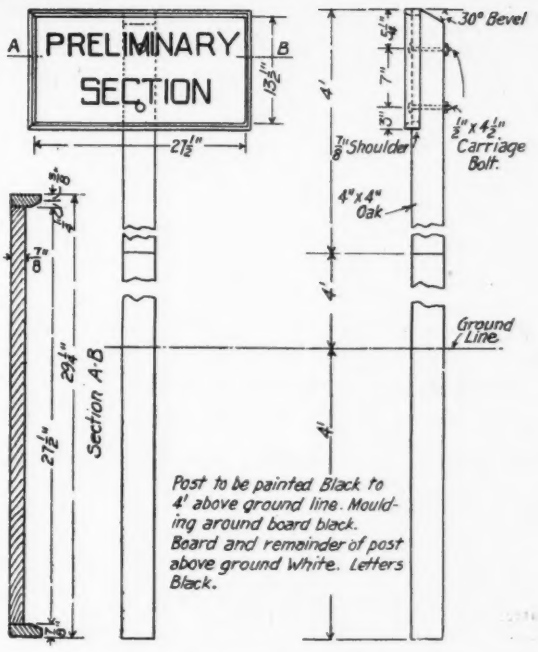


Fig. 349. Preliminary Section Board, Santa Fe.

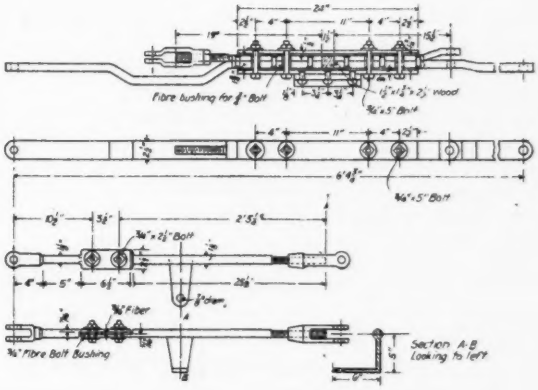


Fig. 353. Insulated Switch Rods, Santa Fe.

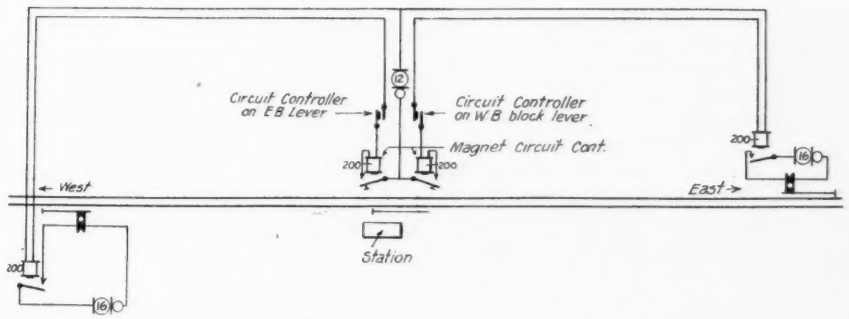


Fig. 357. Circuits for Two Power Operated Distant Signals at Block Station, Santa Fe.

Fig. 337. Layout of Signal Foundation, Cable Post and Battery

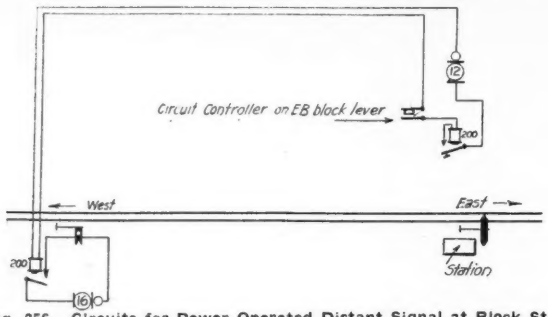


Fig. 356. Circuits for Power Operated Distant Signal at Block Station, Santa Fe.

ELECTRIC SIGNALING FOR ELECTRIC RAILWAYS.*

(Continued.)

Installations of Signal Systems Using Alternating Current Track Circuits with Direct Current Propulsion.

North Shore R. R., California.

The first installation of a. c. track circuits with d. c. propulsion was on the North Shore of California, during the latter part of 1903, between Sausalito and San Anselmo. The system comprised 30 signals, covering a territory of 10 miles of double track and about two-thirds of a mile of single track through a tunnel. Some of the trains running on this line were propelled by steam and others by electricity, using the rails as the return conductors. The steam line was narrow gauge and the electric line standard gauge, providing two rails on each track for the return of the propulsion current, and one rail for track circuits.

In the development of this system the fact was recognized that the problem consisted chiefly in overcoming two difficulties; that of the direct current drop in the rails which would have an undesirable effect upon the alternating current apparatus and that of the low insulation resistance between the insulated block rail and the return rail. The value of both of these factors was necessarily variable, and at that time to a large extent unknown, but from data obtained under favorable working conditions (after the system was in service), it was found that in both respects a considerable margin above the failing point had been secured. The rail which was common to both gauges was divided into block sections. Thus trains of either gauge and whether propelled by steam or electricity, would operate the signals.

Power Supply.

Current for moving the electric trains, as well as for working the signal system, was generated at the famous Colgate power house, distant about 180 miles in the Sierras. The current was transmitted at about 40,000 volts at 60 cycles to the local power house near the tracks, and there stepped down to 4,500 volts. For the signal system connections were made to the neutral and one side of the three-phase system, giving about 2,300 volts single phase. At this voltage the electrical size of the wire required for the signal mains was less than that necessary for mechanical strength. In addition to supplying the track circuits, these mains served to supply current for lighting the signals.

Transformers.

A transformer was placed at the exit end of each block section, the primaries of which were connected across the 2,300 volt wires mentioned above, and the secondaries across the rails of the track circuit. Across the rails at the other end of the track circuit the track relay was connected which operated inductively to close the local circuit controlling the signal.

*From committee report to Railway Signal Association.

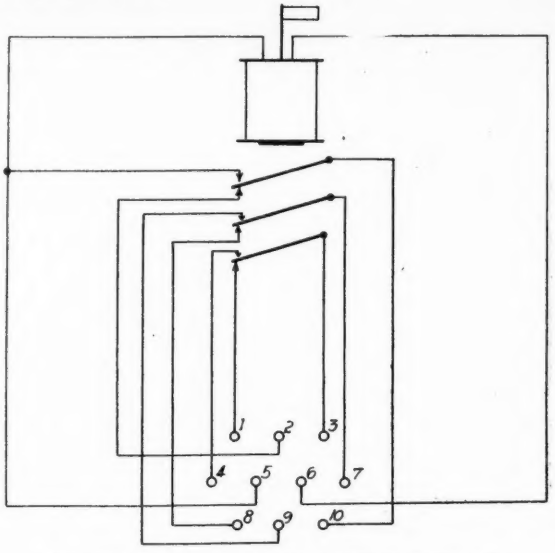


Fig. 355. Circuits for Stick Indicator, Santa Fe.

Track Relays.

Vane type single-phase relays were used in this installation.

Track Circuits.

Some of the track circuits were aboue one mile in length, and as copious rains are frequent during the wet season, conditions were favorable for a test of the system. Ballast was of gravel well removed from contact with the rails. Under the worst conditions the relays operated with a margin of about 30 to 40 per cent or more, above the failing point.

The signals were made effective for trains of either gauge by insulating the rail which was common to both gauges into block sections, thus forming one side of the track circuit and by bonding together the other two continuous running rails for the other side of the track circuit. These rails thus performed the double duty of serving as conductors for the alternating current track circuit and the direct current return propulsion.

Signals.

The signals are of the Union Switch & Signal Co.'s style "B" electric semaphore type, operated by eight volt storage batteries, two sets of which were set in the base of the signals. Where two signals were opposite each other, one battery served for both. They were charged at a rate of 1-5 ampere, through resistance from the 500-volt contact rail. During certain hours of the night the electric train service was shut down, while the steam service continued. Storage batteries thus kept the signals operating while the contact rail was de-energized.

New York Subway.

The system in the New York subway was installed in 1904. Owing to the fact that space was limited it was found necessary to design special apparatus. This system was installed by the Union Switch & Signal Co. and comprised about 700 electro-pneumatic signals (home and distant), and 40 interlocking plants on 70 track miles. The traffic on this line is undoubtedly the heaviest in the country, as for example, at 96th Street 115 to 120 trains pass this point each hour during the rush hours.

Power Supply.

Single-phase 60-cycle current is used for the track circuits and for lighting the signals. This is supplied by turbo-generators in the main power house, and delivered to the sub-station at a potential of 11,000 volts. The generators carry a constant load, and are entirely independent of the motive power circuit; therefore, the electro-motive force is

constant. In the sub-station the alternating current is stepped down by oil-cooled transformers with a ratio of 20 to 1 to 550 volts, and delivered at this potential to the signal cables which extend through the subway from sub-station to sub-station. In normal operation the transformers in all sub-stations are on the signal mains in multiple, and each station is provided with switchboards on which are mounted the necessary switches, circuit controllers, ammeters, synchroscopes, all of which are so connected that any sub-station can be cut off the line at any time, without interfering with the connection between adjacent sub-stations.

In case the 11,000-volt 60-cycle cables leading from the main power house to the several sub-stations should break down, there is provided for reserve power in each sub-station a 25-k. w. transformer, which is connected by an oil switch to the 25-cycle 11,000-volt power circuit. This, at a potential of 550 volts, can be thrown on to the signal mains by reversing a double-throw switch. The reversing of this switch cuts the 60-cycle transformers off, and the 25-cycle on the signal mains. The 25-cycle current is not intended for constant operation, as results from its use are not so satisfactory as from the 60-cycle current. This is on account of the considerable voltage fluctuations of the power current. The frequency being lower, the energy consumed when operating the signal system by it is increased about 66 per cent.

A transformer with two secondary coils is placed at the exit end of each block, the primary coil being connected across the alternating current mains. Cut-outs and fuses are placed in each of the primary connections. One of the secondary coils supplies current to the rails for track circuits at a potential of about 10 volts. The other is for lighting the signals at 50 volts. In the circuit between the transformer and the block rail is a grid resistance of one ohm and a 50-ampere 500-volt fuse. The purpose of the resistance is to prevent a dead short circuit in the secondary coil of the transformer, when a train is in the block. At the signal end of the block, the alternating current passes from the rail through a 50-ampere fuse to a grid of one ohm resistance, then through a relay and impedence coil which are in multiple to the return rail; then through this rail back to the transformer or point of starting. The impedence coil has a winding of very low ohmic resistance around a laminated iron core, and is placed in the circuit in multiple with the relay to prevent a harmful amount of direct current from passing through the relay.

Relays.

Vane type single-phase relays are used, which consist of two-pole pieces, which are made up by winding coils of wire around laminated iron cores between which an aluminum vane moves through a quadrant of a circle. This vane is supported on jeweled bearings and mounted on its shaft, but insulated from it by lavite insulation.

Track Circuits.

The blocks average about 820 feet in length, their lengths being equal to braking distance plus 50 per cent when a train is making the greatest speed possible for it to attain at a given point. Grades are taken into consideration in making these calculations.

Battery Supply.

All relays (except alternating), signal valves, automatic stop valves and switch valves are operated by direct current from storage batteries, at a potential of 16 volts. These batteries are connected in multiple to two mains which extend throughout the length of the subway. At or near each interlocking station batteries have been placed consisting of two sets of eight cells each, also one motor generator and switchboard with the necessary starting and controlling rheostats, charging and discharging switches, ammeters, voltmeters, overload charging circuit breakers, etc. The batteries are of sufficient capacity to operate the system for five days without recharging. Battery stations are so situated that should any one be disabled, the adjacent station will supply all necessary current to keep the signals and interlocking plants operating until the disabled batteries can be replaced.

The cables and battery wires are supported by span wires along the center line of columns on the side opposite the main air pipe. Wooden conduits are used for all wires and cables.

Air Compressors.

The compressors for supplying the compressed air are situated in the basements of the sub-stations. They are motor-driven, automatically controlled machines, each with a capacity of 230 cu. ft. of air per minute. All compressors are connected to the air line at all times, but the automatic controlling device on each compressor is adjusted so as to stop the machine when the pressure reaches a predetermined point, and start after the pressure has fallen to a predetermined point, which is considered the minimum pressure allowable. The device which automatically controls the compressor also automatically cuts in the supply of water which is necessary for cooling purposes. These compressors are always started against no load, and it is only when they have reached their rated speed that the road is automatically cut in. This arrangement is considered the most economical in the use of power and of water that has to date been devised for the operation of air compressors.

The compressed air for operating switches, signals and automatic stops, is supplied from the main pipe line which extends throughout the length of the subway. This main is placed along the center line of columns at the bottom of the knee braces. The pipe used in the construction of this main is 2-inch extra heavy galvanized iron with extra heavy galvanized fittings. Bends are used to take care of expansion and contraction in the pipe and the customary expansion joints are used where it is found inadvisable to use expansion bends. All branch pipes leading from the main air pipe to the various stops, signals and switches, are ½-inch heavy, galvanized. The manifold condensers for cooling the air after it has left the compressors are placed in the subway opposite the sub-stations. Between these condensers and the sub-stations under the city streets are two lines of 3-inch extra heavy galvanized pipe, surrounded by three inches of concrete. These precautions were taken to avoid having the pipe damaged by digging up the streets to repair gas, water and other pipes.

On the express tracks south of 96th street and on the local tracks north of that point, where the stations are a considerable distance apart, a complete overlapping system of block signaling is used. At other points on the local tracks, only straight blocking is installed. Automatic trips are used in connection with all overlapping block and interlocking signals.

West Jersey & Seashore.

The system on the West Jersey & Seashort between Camden and Atlantic City, N. J., was installed during the year 1906. This line was equipped by the General Electric Co. for electric traction. The block signal apparatus was installed by the Union Switch & Signal Co. throughout, and with interlocking for switches and signals (semaphore type) at all important stations on the line which had not already been equipped. From Camden to Newfield (30 miles) the block signals installed were automatic, electro-pneumatic, normal clear, with 120 block sections, the sections averaging 4,000 feet in length. From Newfield to Pleasantville the telegraph block system was used with manual home signals and electric motor distant signals. From Pleasantville to

Atlantic City the signals installed were of the same type as between Camden and Newfield.

Power Supply.

Air compressor plants were installed at Camden, Newfield and Atlantic City. The compressors at Camden and Atlantic City are direct connected steam driven (duplex type), and the ones at Newfield are motor driven (belt connected).

Transformers.

Transformers, in duplicate, for stepping down from 33,000 to 11,000 volts single-phase high-tension circuits are located at the South Camden, Westfield, Glassboro and Newfield sub-stations for the section of road between Camden and Newfield, and in the sub-station just north of Atlantic City for the signals and interlocking plants between Pleasantville and Atlantic City. The connections to the transmission, or 33,000 volt lines, are such that by proper switching, either transformer at any of the above sub-stations can be made to take current from either of the two high-tension circuits.

With the exception of the sub-station at Newfield, which is at the south end of the line between Camden and Newfield, an 1,100-volt feeder circuit is run in each direction from each of the sub-stations. Switchboards from which these circuits are run are so designed that if it should at any time become necessary, the transformers at one of the sub-stations of the section between Camden and Newfield can be cut out, the distance between substations being such as to permit of this without any undesirable effect on the working of track circuits.

Track Circuits.

The track circuits are of the center fed, two-rail return type, averaging about 4,000 feet in length, with a wire-wound armature type relay at one end and a step-up transformer at the other. The step-up transformer is connected to the relay by line wire furnishing the current for the field winding. Relays are of the wire wound armature type.

Long Island, No. 1.

During 1906 automatic electric block signals were installed by the Union Switch & Signal Co. on the electrified lines of the Long Island from Brooklyn to Howard. A third rail is used for delivery of the propulsion current and both of the running rails are used as return conductors.

At that time there were 19 miles of double track and 4½ miles of four-track road, the length of the track circuit sections ranging from 1,000 to 1,200 feet with transformers connected at one end; track circuits ranging from 1,300 to 2,800 feet have the transformers connected in intermediate positions.

Signals.

The signals are of the Union Switch & Signal Co.'s style "B" type, with the exception of those in the two subways on Atlantic avenue where the electric light type are used.

Battery Supply.

Current for the motor and line relay is taken from a set of storage batteries located at each pair of signals, so arranged (batteries in duplicate) that one set is charging while the other is discharging. The charging current is taken from the third rail at 650 volts through a high resistance so proportioned that the necessary charging current will flow into the battery.

Power Supply.

A 100-k. w. transformer supplies the high tension mains at 2,200 volts—25 cycles. These mains are placed underground in a lead-covered cable for a distance of about eight miles and the remainder of the distance carried on high-tension transmission pole line. From the alternating current main taps are brought to the primary transformers where the potential is reduced to 55 volts. This in turn is reduced by another set of transformers to a voltage of from six to two volts as the conditions of the different track sections require.

Long Island No. 2.

From The Raunt to Valley Stream, L. I., in 1908, the Union Switch & Signal Co. installed signals with three-position track relays, semi-wireless control, as shown in Fig. 17. Referring to Fig. 17 it will be noted that the track transformer is attached to the rails near the middle of the track circuit and that galvanometer type of relay is used at each end, the one at the exit end of the track circuit being the two-position and the relay at the entrance end a three-position relay. The armatures of the relays are energized directly from the track circuit and the field of the relay at the exit end is energized directly from the 55-volt transformer. The field of the relay at the entrance end of the track circuit is energized over the line wire extending up to the exit end of the track circuit and through the point of the relay at this end; thence, through the pole changer to the 55-volt transformer. (See description of galvanometer relay.)

Long Island No. 3.

From Woodside to Jamaica, L. I., is an electric and steam line, and a portion of it is four-track, double-track and 6-track. The signal system here was installed by the General Railway Signal Co., in 1909.

Power Supply.

The power is supplied from a 2200 volt, 25-cycle alternating current line, which is strung on cross-arms of the high tension pole line along the right of way, it being delivered from the sub-station.

Arrangement and Type of Signals.

Signal-arm, three-position, upper right-hand quadrant signals are used, being operated by model 2-A a. c. mechanisms, placed at the base of pole. The arm is operated by an inside rod. One of the features of the signal is that it is held clear by allowing the current to flow through the armature, reducing the voltage across the armature at such times by a small auto transformer. The control of the 90 degree position of the signal is taken from a line connected to the circuit controller of the signal in advance, direct to the motor fields.

Track Circuits.

One of the essential features of this installation is that the two-rail track circuits are being operated with balanced core impedence bonds and are end-fed at a length of over 5,000 feet. The impedence bonds have 10 turns of copper with a section of 900,000 C. M. Where switches are in a block section the energy for the local winding of the track relay is broken through controller boxes at the switches. At interlocking plants the polyphase relays are in the interlocking station and are used as a visual and audible indicators, the relay being supplied with a bar or banner which shows through vertical slots on the front glass of the relay, either red or white, depending upon the de-energized condition of the relay. This makes the relay a visual indicator, which shows whether the track is occupied or unoccupied. The relays are also equipped with contacts of such construction that when de-energizing they will make contact, but when energizing will not close the contact.

Transformers.

The line transformers are designed for feeding four tracks; that is, they have four separate secondaries for track circuits, and are also provided with one secondary, giving 169 volts for signal operation, with a 55-volt tap for signal lights and 17 volts for the local winding of the polyphase relays.

Signals at Interlocking Plants.

Interlocking signals are 110 volts d. c. model 2-A, and are held clear by the motor armature. This is accomplished by

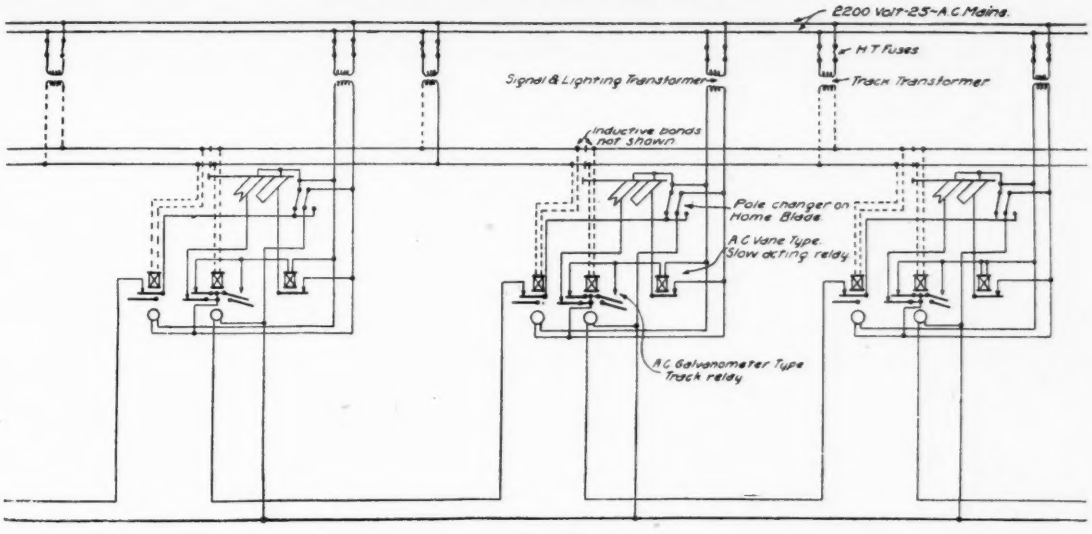


Fig. 17.

having two working fields and two high resistance fields, on which the coils are put on a corrugated pole piece. When signal clears, the energy is cut off from the working field and is then forced through the high resistance fields and working fields in series, and holds the armature from revolving in either direction. The indication used on signals is a. c. using a solenoid indication magnet. In some cases a number of sgnals are indicated in series. For example: where routes converge at the interlocking plants as many as 6 signals are indicated in series. All dwarf signals employ a. c. indication, arranged in the same manner as the high signals.

Philadelphia Rapid Transit.

During 1907 the Philadelphia Rapid Transit Co., installed on part of their subway and elevator division automatic block signals; from 69th street to the City Hall loop, completing the line to South street during the year 1908, the installation comprising 205 signals, 75 of these being in the subway, including 97 train stops, and 8 interlocking plants.

With the exception of the light signals in the subway, all the block signals and automatic train stops, as well as the eight interlocking plants are of the electro-pneumatic type.

Power Supply.

Direct current for controlling the different functions is provided by six duplicate sets of seven cells each, Type "5-E Chloride Accumulators," placed at convenient distances along the line. These batteries are charged through a resistance from the 550-volt direct current available from the third rail. The duplicate sets are, of course, arranged to operate alternately, one being charged while the other is discharging. A twin cable of No. 6 wires runs the entire length of the road and the six sets of batteries feeding it in multiple deliver, approximately, 14 volts at all points in the system.

Compressors.

The air for operating the different functions is normally furnished from two compressor plants—one, a duplicate set of steam-driven compressors installed in the Philelphia Rapid Transit Co.'s direct current generating station near 32nd street, while the other, a duplicate set of motor-driven compressors, is housed in a specially constructed compartment under the tracks where they emerge from the subway near Water street. An additional steam-driven compressor for emergency use is at 69th street. The air is conveyed to the elevated structure where a 2-inch pipe, extending the length of the system delivers it at a pressure of from 85 to 90 pounds per square inch, for operating each mechanism. If the pressure of the line falls to 50 pounds per square inch, the emergency compressor is automatically started to build it up. When the normal pressure is again reached throughout the line, this compressor cuts out automatically.

Circuits.

As the trains are propelled by direct current fed by a third rail, the installation of alternating current for track circuit operation was necessary, the signal-rail return system being used. The a. c. signal mains are No. 5 line wires strung on insulators supported from the structure from 63rd street to the mouth of the subway. Through the tunnel, the insulators are placed on special brackets clamped to the columns supporting the roof, or hung directly from the roof. Alternating current at 1,100 volts and 25 cycles is fed into these mains from the 56th street sub-station on the up-town section of line, and from the generating station on Samson street, near 8th street, on the down-town section. Both of these power plants are the property of the Philadelphia Rapid Transit Company. As the absence of a suitable pole line and other local conditions prohibit the high voltage from being carried further west than 63rd street, where the road desecends to the surface, the pressure of the signal mains is stepped down from 1,100 to 220 volts at this point, and the current for the track circuits taken to the 69th street terminal by a twin cable placed in wood trunking. This condition necessitates the design of the signal transformers to operate on 220 volts for one section of the line, while the majority of the track sections are fed from transformers operating with 1,100 volts on their primary.

The operation of the relay is not affected by the presence of direct current in the circuit, but in order to limit the amount passing through the relay so that it will not become dangerously overheated, it is shunted by an impedence coil and a resistance is inserted in the lead running to the block rail. A 50-ampere 600-volt fuse protects the relay and impendence coil from any excessive current which might damage the apparatus.

Signals.

The signals on the elevated and surface portion of the electro-pneumatic type. Their design differs but little from the Union pneumatic ground signal, the signal posts being somewhat shorter and the base of a different style, arranged to fit the conditions arising in signaling for elevated structures. The position indication of the semaphore arms is supplemented by a color scheme for night operation.

The subway is signalled with a light signal having no moving parts. It consists of a cast-iron case which, for home

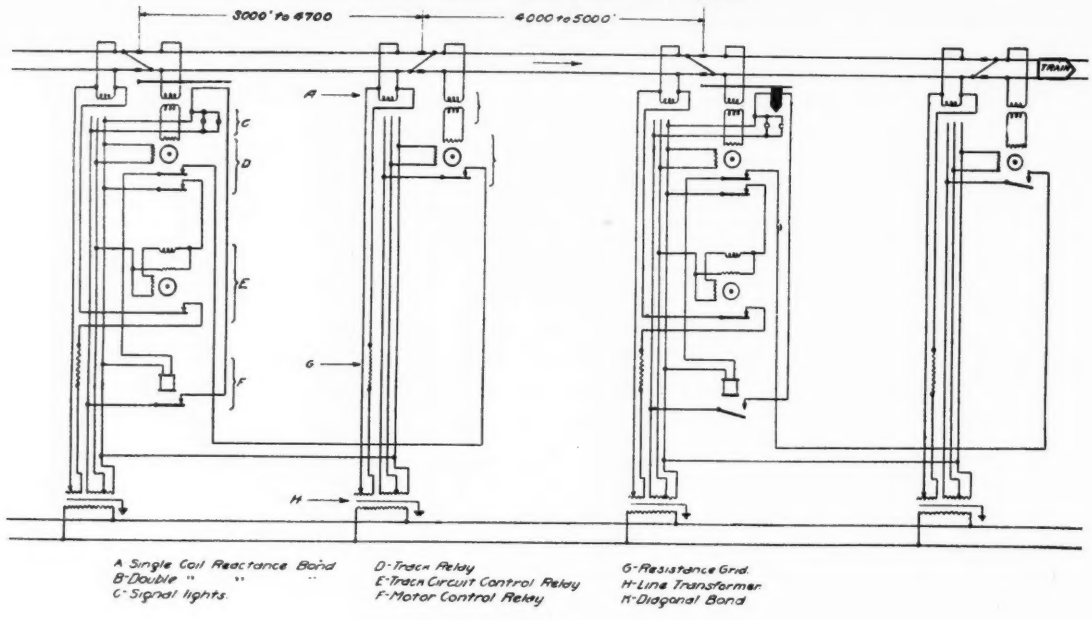


Fig. 18.

and distant indication, has four lenses, directly behind each of which two incandescent lamps are mounted. In a compartment in the rear of the lamps, and separated from them, a relay is placed for operating the lights of each set of lenses. The home relay is controlled by the track relays and when a train has passed out of the block ahead of the signal to give a clear indication, the signal relay picks up, feeding current through its front contacts to the lights mounted in the rear of the green lens. When, however, the signal relay circuit is open, i.e., when a passing train has not cleared the overlap point, the lamps behind the red lens are lighted by current over the back points of the relay, thus displaying a stop signal. The distant indication is obtained through another relay in the same manner. Other front and back contacts of the controlling relays are available for performing the functions of ordinary circuit controllers on a moving signal mechanism.

Each home signal has an overlap of one block and at each station an additional track section is provided in the home block. This arrangement not only allows of sufficient distance (approximately 700 feet), to stop a train running at the maximum operating speed, but also enables a second train approaching one which has stopped at a station to come up to the first home signal block of the station. This precludes the necessity of a train having to wait two blocks in the rear of the station, for as soon as the first train has passed out of the supplementary track section, the second can at once proceed. East of 15th street, the signals are placed a train's length in the rear of the track section by which they are controlled. This gives a partial protection of the overlapping scheme without the addition of extra track sections.

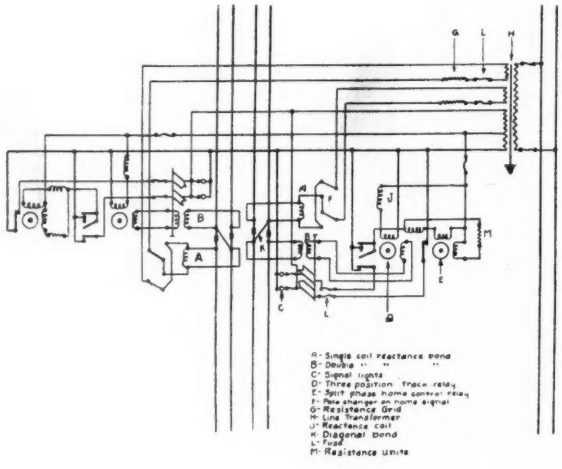


Fig. 19.

New York, New Haven & Hartford.

During 1908 the New York, New Haven & Hartford put in an installation between East Hartford and Vernon, a distance of eight miles, this installation being a. c. stepping down from a 10,000 volt power transmission line to a 2,200 volt transmission line for signaling purposes. The signals are operated and also lighted directly by 110-volt 60-cycle alternating current. At each of the junctions, East Hartford and Vernon, there are installed mechanical interlocking plants for the operation of switches and signals, and the automatic semaphore signals between the stations named are spaced at intervals of from 3,700 to 5,200 feet.

Transmission Lines and Power.

Throughout the entire length of the signaled section there is installed a 10,000-volt, three-phase, 60-cycle commercial line, giving a reliable 24 hour service. From this supply current was furnished for the signal system, the connection being made through step-down transformers. The transformers are connected to one phase of the high potential line, stepping the current down from 10,000 volts to 2,200 volts, and connected through oil switches to the signal transmission lines which extend the entire length of the signal system. From this 2,200 volt, 60-cycle line current is obtained through transformers for the various signal requirements.

Track Circuits.

The track circuit equipment installed is designed to be used with a propulsion current either direct or alternating, either 550-volt direct or 11,000-volt, 25-cycle single-phase alternating. The electric railway company required that the tracks be cross-bonded at least every 3,000 feet, thus making necessary a cut section, in each block. Energy is supplied to the tracks by a transformer situated in the middle of a

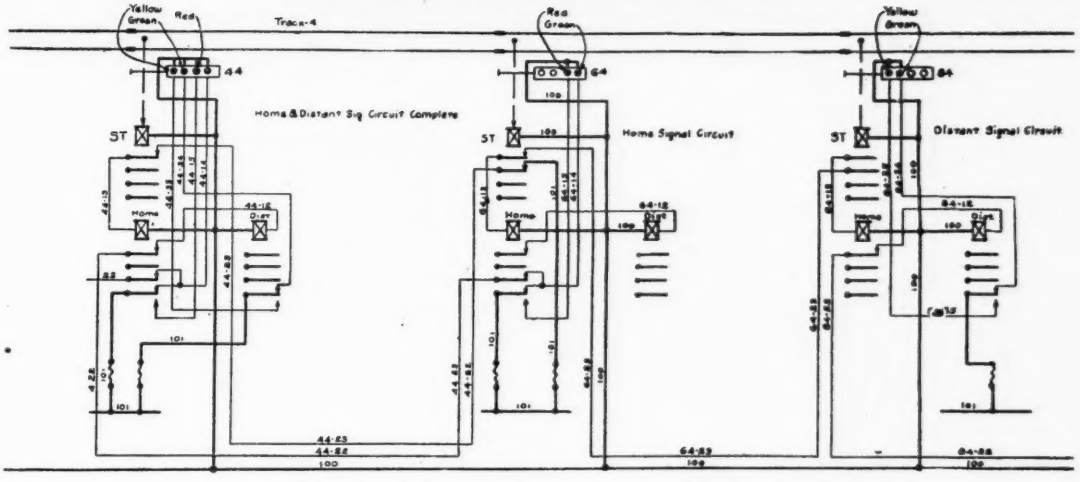


Fig. 20.

track circuit section, with a relay at each end. These control the signal circuits. At each end of the track circuit there is also an impedence bond, the terminals of which are connected to the rails and the center of which is connected to the center of the bond of the next track circuit, thus forming a metallic connection around the insulated rail joints for the return propulsion current. This center connection may also be used for cross bond taps. The impedence bonds were designed to carry the heavy current necessary with direct current propulsion and also perfectly balanced to offer the least possible impedence to an alternating propulsion current.

The frequency relays are absolutely immune to a direct current or to alternating current of 25 cycles, having been designed to operate at 60 cycles. The unbalancing of the track, therefore, even if sufficient to throw a heavy current through the frequency relays, would not result in a false clear signal indication. This system will, of course, be not in the least affected by any foreign trolley current. In connecting the impedence bonds to the rails, use is made of an old rail about 15 feet long. To connect up an impedence bond to a track with broken or staggered joints, it is necessary either to cut one rail of the track so as to have the insulated joint near the bond, or to provide a conductor from the bond to connect with the track beyond the insulated joint which may be some 15 feet. The piece of steel rail is better than copper because it costs less and is not liable to be stolen, and besides, if alternating current is used for propulsion, the iron serves to restore the balance of the inductance of the two lines of rails, which with one side 15 feet shorter than the other, would be unbalanced.

Signals.

The automatic equipment consists of home and distant signals mounted on the same post. The eastbound and westbound signals are placed nearly opposite, but are staggered sufficiently to avoid putting a signal where a trolley pole will obscure it from the engine-man. The blade grip castings are designed to permit the arm to extend to the left of the post for the reason that the trolley poles would obstruct the view of the signal if it extended only to the right.

At each signal there is a transformer, stepping down the current from 2,200-volts to 110-volts to supply current for the local signals and the control circuits for the next signals in the rear. All wire connections between transformers, signals, tracks and the signal control circuits are in wood trunking. The signal control line extends the entire length of the block section, taking energy at the outgoing end and looping through the track relays and switch instruments.

Philadelphia & Western.

This installation (1907) is on a double track, high speed direct current electric line, extending westward from Union station at 69th street, Philadelphia, to Strafford, Pa., 11½ miles. Apparatus used in this installation was supplied by the General Railway Signal Company.

Arrangement and Type of Signals.

Single-arm, two-position, lower quadrant, home signals, arranged on the normally clear principle with overlap are

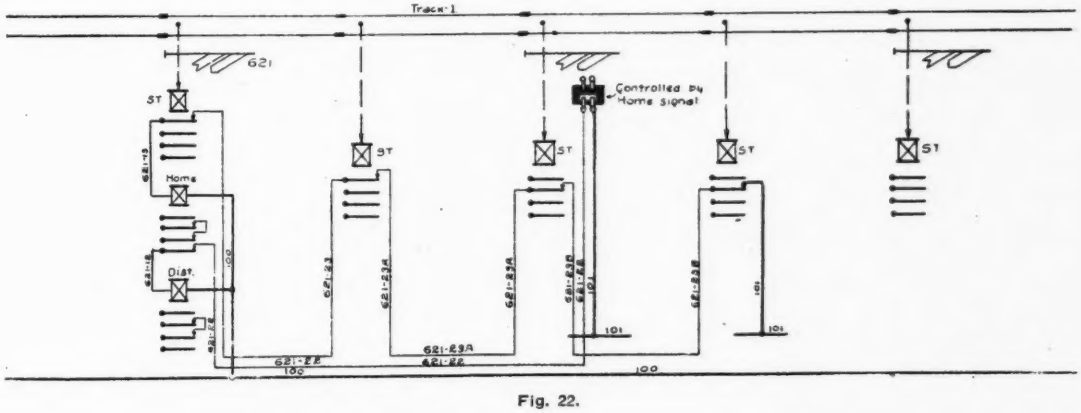


Fig. 22.

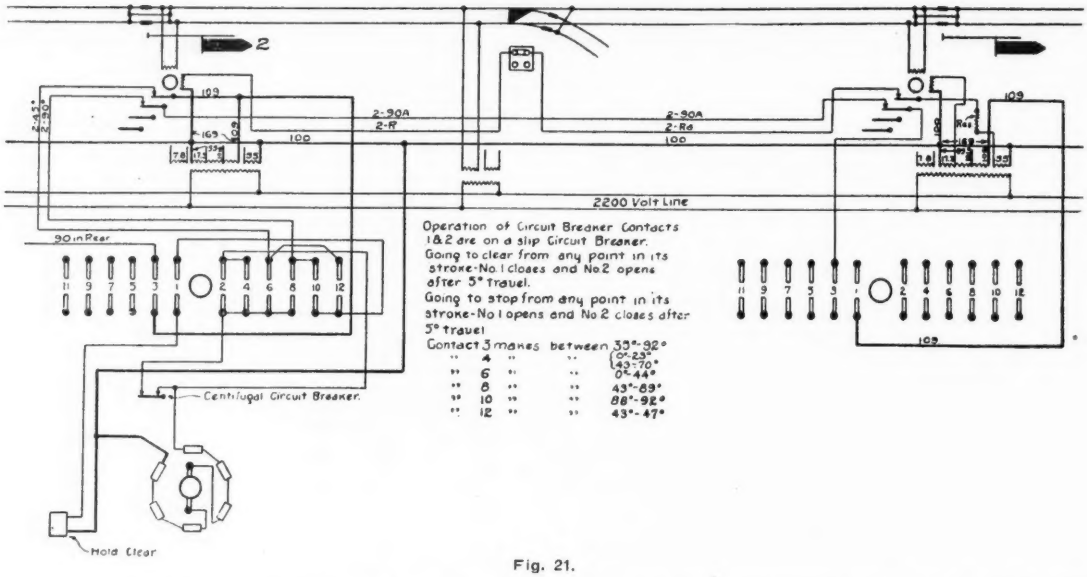

2200 Volt Line
Operation of Circuit Breaker Contacts
1&2 are on a slip Circuit Breaker.
Going to clear from any point in its stroke-No. 1 closes and No 2 opens after 5° travel.
Going to stop from any point in its stroke-No 1 opens and No 2 closes after 5° travel
Contact 3 makes between 33°-32°
" 4 " " 0°-23°
" 6 " " 43°-70°
" 8 " " 0°-44°
" 10 " " 43°-89°
" 12 " " 88°-92°
" 12 " " 43°-47°
90 in Rear
Centrifugal Circuit Breaker.
Hold Clear
2-90A
2-R
2-Ra
100
109

Fig. 21.

employed. Between Philadelphia and Beechwood Parks, the signals average about 3,300 feet full block overlap. West of the park the signal spacing averages 1.5 miles with uniform overlap of about 3,700 feet.

Power Supply and Distribution.

Twenty-five-cycle single-phase alternating current is used for the operation of the entire signal system as above mentioned. It is obtained from the secondaries of the railroad company's power transformers in its main power house. Power is delievered to a switchboard through a remote control automatic oil switch. Each feeder circuit is equipped with an ammeter and an electric trip hand-operated oil switch. The transmission line consists of two No. 6 B. & S. gage hard-drawn copper wires strung on separate cross arms on the railroad company's high-tension pole line, the line being protected at intervals by lightning arresters.

Line transformers are installed at all signal and overlap locations. They step down directly from the transmission line voltage of 2,300 volts to the various voltages required for the signal system. The transformers are protected on the primary side by cartridge fuses mounted in water-tight cast iron boxes and so arranged that a fuse can be replaced without danger.

The secondary windings are three in number. A 55-volt winding for the operation of the signal motors, line relays and lights provided with a tap for local phases of all polyphase relays and two windings for supplying energy to track circuits, taps being provided on these windings so that the voltage can be varied from 2.5 volts to 15 volts, as required for track circuits of varying length. A copper shield is placed between the primary and secondary windings and connected to ground to afford protection in case of a breakdown in insulation. The windings have been subjected to an impregnating process.

Track Circuits.

Both rails of each track are made available for propulsion current by the use of coreless impedence bonds. Diagonal cross bonds are so arranged that the breaking down of an insulated rail joint will short circuit either the relay or transformer, preventing the operation of the track relay falsely. Cross bonding between tracks may be affected by making connection at any point desired to the rails, which are made continuous by the diagonal cross bonds. A connecting chamber is provided in the case between the coils of the bond, in which all coils terminate, and where all connections to rails, relays and transformers are made and then concealed by a cover. The copper connections to the rails after leaving the bonds go directly downward and underground to the rails, where after passing for a short distance above ground to insure flexibility, are connected to the rails. Energy is supplied to the track circuits directly from the low voltage high current windings of the line transformer through adjustable cast iron resistance grids which limit the current flow when a train is standing at the transformer. The track circuits are end fed.

Track Relays.

The track relays are of standard polyphase induction type.

Track Circuit Control Relays.

Track circuit control relays are for the purpose of holding a given signal at stop until the train has cleared the overlap. The method by which the control of the signal is affected is shown in Fig. 18. These relays carry continuously and break the entire current flow through the track circuit at the rear of the signal, the contacts being designed to carry alternating current of from 50 to 75 amperes and break it at 25 volts continuously without overheating and without perceptible arcing. The operation of these relays is similar to that of the track relays, except that the contacts are made very much heavier, as previously noted, and the necessary phase displacement to produce rotation is affected by a small reactance coil placed in series with one of the relay windings.

Motor Control Relays.

The motor control relay, which is of the alternating current type, is controlled by the various track relays. This relay directly controls the clearing of the signal, it being so designed that a uniform magnetic pull is exerted on the armature, notwithstanding the fact that the current in the magnetic coil alternates. In many respects this is similar to track and line relays of the direct current type.

Signal.

The signal mechanism employed is an adaptation of the two-arm No. 6 mechanism, with a 50-volt induction motor.

Relay Housings, Stub Posts, Etc.

All relays are housed in wooden boxes, which in turn are enclosed in cast iron boxes. In the lower part of the iron boxes are mounted terminal boards where all wires terminate on binding posts and to which all apparatus within the boxes themselves are connected by flexible leads. All transformer secondary fuses are also mounted on this board. Relay

boxes, grid boxes and line transformers are mounted one above the other on wooden posts.

Circuits.

The various circuits employed for the control of signals are shown in Fig. 18.

Nankai Railway of Japan.

This installation (1908) is on a double track, high-speed direct-current electric line, extending from Hamadera to Namba in the province of Settsu in central Japan, a distance of 9½ miles. Apparatus used in this installation supplied by the General Railway Signal Co.

Arrangement and Type of Signals.

One-arm, two-position, lower quadrant, and two-arm home and distant signals, normal clear with no overlap are employed, the average length of block being 2,300 feet.

Power Supply and Distribution.

Sixty-cycle, single-phase current is ued for the operation of the entire signal system, being obtained from a duplicate direct current to alternating current motor generator set located at the power house. The transmission line consists of two No. 6 B. & S. gage, hard-drawn bare copper wire, strung on cross arms on the railroad company's high-tension transmission line, being protected at suitable intervals by high-tension lightning arresters.

Line Transformers.

See same heading under Philadelphia & Western system.

Track Circuits.

Similar to those on the Philadelphia & Western. See circuit plan, Fig. 19.

Track Relays.

The track relays are of the polyphase induction type arranged for three-position operation, which is accomplished by reversing the polarity of the track winding by a circuit controller on the home arm of the signal in advance. The sector is mounted vertically and operates in either direction, depending upon the polarity applied to the track winding. When the track winding is de-energized or shunted by the train, the sector drops to the vertical position; this operates the contact bar and cuts off the energy of the slot for the home and distant arms, causing them to assume the stop position. When the train clears the section, current of the proper polarity is applied to the relay, causing it to pick up in the direction to complete the circuit of a slow acting split phase relay which in turn completes the motor and slot circuit controlling the home signal. When the home arm of the signal in advance clears, the polarity of the track circuit is reversed and relay operates in the opposite direction through an arc of about 90 degrees. This throws energy on both the home and distant slots. The home arm is prevented from assuming the stop position by the slow acting relay, which does not open during the short, interval taken by the contact bar of the three-position track relay in swinging from one extreme position to the other, energy being applied to the slow acting relay in each extreme position. The slow acting relay is necessary in order to prevent de-energizing the slot for the home arm while the contact bar is operating from one position to the other.

Slow Acting Relays.

These are polyphase relays, operated locally by split phase relays, reactance being connected in one of the phases and resistance in the other, as shown in the circuit plan, Fig. 19. The energy for these relays is controlled through either of the extreme positions of the contact bar of the track relay.

Signals.

The mechanism is the standard No. 6. type with a 50-volt

Relay Housings, Stub Posts, Etc.

Similar to those on the Philadelphia & Western system.

Electric Zone, N. Y. C. & H. R. R.

This installation is on a four-track, high speed, direct current electric line, approximately 12 miles long, between New York city and Wakefield, N. Y., also 6 miles, from Mott Haven to Spuyten Duyvil, N. Y. Apparatus used in this installation was by the General Railway Signal Co., and was installed in 1906.

Arrangement and Type of Signals.

Two-arm, two-position home and distant signals, are near normal clear, employing full block overlap, with the exception of a tunnel, approximately two mies long, in which home and distant signas of the light type are used. The average length of block is 1,200 feet.

Power Supply and Distribution.

Twenty-five-cycle single-phase alternating current is used for the operation of the entire signal system. It is obtained from the secondary of transformers in the various signal sub-stations adjacent to the main power sub-stations. The power is delivered to the primary of a static transformer through a remote control automatic oil switch, the voltage being stepped down from 11,000 to 2,200 volts, the 2,200 volts being delivered to the power line through an electrically tripped hand-operated oil switch. Each feeder circuit is equipped with an ammeter and voltmeter. Direct connected d. c.-a. c. motor generator sets are also installed in the signal sub-stations to anticipate the interruption of the 11,000 volt line, the motor being normally fed from 650 volt traction storage battery located in the main power sub-station. The generator is of the revolving field and stationary armature type, the fields are excited by a small direct connected generator.

Synchronizing apparatus is provided so that the feeders can be put in step when energized from motor generator sets. The transmission system consists of both underground and aerial transmission lines, the underground line having a twin conductor lead-covered cable of stranded No. 0 wire placed in vitrified ducts, or pipes, the pipes in many cases being exposed and in others placed in concrete. The aerial line is run on cross arms placed on the steel towers carrying the high-tension transmission line from power house to various sub-stations. The line consists of two No. 0 solid conductor bare copper wires protected at intervals by lightning arresters.

The signal sub-stations are approximately five miles apart. The transmission lines are brought into the sub-station on a terminal board in such a manner as to make it possible at any time if desired or found necessary to cut out a sub-station and let the adjacent station or stations work through. The transmission line is interrupted at sub-stations so that normally each sub-station feeds both ways, being independent of its neighbor. This is to avoid the need of keeping them in synchronism in case the emergency motor generator sets are used.

Line Transformers.

Line transformers are installed at all signal and cut section locations. They step down directly from the 2,200-volt line, through fuses placed in cast iron boxes, to 50-volt bus lines, which are run from the secondary to feed the motors, slots, line relays and lights, also the primary of the track transformer. A copper shield is placed between primary and secondary windings and connected to ground to afford protection in case of a breakdown in insulation. The windings are subjected to an impregnating process.

Track Transformers.

Where both rails are used for the power return, the track transformers are wound for a primary pressure of 50 volts, with a secondary winding for 1⅞ volts and one winding with taps for various voltages from 0.45 volts to 6 volts. The transformers have a closed magnetic circuit and are provided with slate terminal boards, having binding post for each terminal or tap. They are oil cooled and kept in water-tight iron cases and are provided with 6 flexible outgoing leads.

Where but one rail is used for the power return, the transformer is wound for a primary pressure of 50 volts and secondary pressure of from 0.45 volts to 12 volts, also a secondary winding is provided to give a potential of 1⅞ volts to feed the line or local side of the polyphase relay, and an air gap is maintained in the magnetic circuit to prevent saturation from propulsion current when an excessive amount of propulsion current is caused to be shunted through the signal rail. The type similar to that employed when both rails are used for power return. The primary windings of either transformer are protected by fuses placed on a terminal board at the bottom of the track box.

Impedence Bonds and Track Circuits.

See description of core bonds, above. The track circuits are of the end-fed type and do not exceed 1,600 feet in length.

Track Relays.

The track relays are of the polyphase induction single contact type. They are used as primary relays to operate secondary or repeater track relays. For description of operation see polyphase relays, above.

Secondary and Motor Control Relays.

Alternating current, 25-cycle, tractive relays are used to control energy delivered to motors and slots, it being so designed that uniform magnetic pull is exerted on the armature. In many respects it is similar to direct current track and line relay.

Signals.

Where mechanisms are employed, No. 6 mechanism (General Railway Signal Co.) with a 50-volt induction motor is used. Where light indications only are given, cast iron boxes are used, equipped with red and green or yellow and green lenses, behind which are placed either 2-3 c. p. or 16 c. p. 50 light volts. These lights are controlled directly through the front and back contacts of the secondary or line relays. These relays are controlled through the contact of the track relay. See Fig. 20.

Relay Housings and Cable Junction Boxes.

A cast iron box is used for housing the track transformer and also the track relay which is enclosed in a separate wooden box. This box, known as a track box, also contains the terminal board on which all incoming and outgoing wires are connected. Where two rails are used for power return, the resistance grid is placed upon the top of the wooden box which contains the relay; where but one rail is used for power return, a coreless impedence bond is used and placed upon the top of the wooden box which contains the track relay and the iron resistance grid is placed in a separate cast iron box properly ventilated and bolted to the track box proper, the track boxes being mounted on pedestals. The secondary and line relays are housed in wooden boxes with a terminal board arrangement for making connection from the incoming and outgoing wires to the contacts of the relay. Where aerial construction for line wire is used, lightning arresters are located at the bottom of the relay box. In either case, fuse boards, arranged for enclosed type fuses are placed in the box.

Circuits.

See Fig. 22.

Grand Central Terminal.

Track Circuits.

In connection with the all electric interlocking on this terminal for controlling automatic signal indications, route and lever locking and providing indications for illuminated track and director diagrams 25 cycle a. c. at 300 volts is used. Wires are run in pipes or ducts and are in No. 0 stranded copper rubber-covered lead cable. The transformer primary is 300 volts to 50 volts secondary, the 50-volt bus line being run to feed the various track transformers and signal lights. A center tap is taken from the 50-volt secondary windings to light 25-volt, 1 c. p. lights which are used in the illuminated diagrams. The power board is in the basement of the main sub-station and the 300 volts delivered from the 11,000-300 volts static transformer through oil switches. In case of emergency a motor generator set has been installed which is fed from the 650-volt emergency sub-station battery.

Single-rail track circuits are used for switch locking and automatic signal circuits and check locking between interlocking stations. The standard polyphase relay, induction type, is used with two different schemes of control.

The single-contact polyphase relay with the transformer placed in a track box at the end of the circuit, the relay being housed in a track box at the entrance end of the circuit with secondary relays located in the interlocking station is used for the control of switches and illuminated diagrams. In the other scheme, transformers are placed at the end of the track circuits with four contact polyphase relays in the basement of the interlocking station and instead of having coreless bonds in multiple with the track winding of the polyphase relay, no bond is used, but an impedence is inserted in series with the local winding to get the phase relation between the track and local windings of the relay. Resistance units are used instead of grids, the units being at the transformer feed and also at the relay in the track winding. These resistances are variable from ¼ to 1 ohm. The secondary circuits are controlled through contacts on the polyphase relay. In the permanent installation, track circuits will be supplied from a central energy source, transformers being at convenient places with various feeds running to the track, the relays being housed in the bottom of the interlocking station or sub-interlocking stations, four contact polyphase relays being used.

Electric Zone, N. Y. C. & H. R. R.

This installation (1910) is on a double track, high speed, direct current electric line between Wakefield, N. Y., and North White Plains, N. Y., a distance of approximately 12 miles. The apparatus used in this installation was supplied by the General Railway Signal Co.

Arrangement and Type of Signals.

One-arm, three-position, upper right hand quadrant home signals are employed. The average length of block is 4,000 feet.

Power Supply and Distribution.

This is the same as the installation between New York and Wakefield and Mott Haven and Spuyten Duyvil, with the exception that a. c.-d. c. motor generator sets are not used, due to the fact that there are no traction storage batteries on that line.

Line Transformers.

Line transformers are installed at all signal and track feed locations. They step down directly from the transmission line of 2,200 volts to the various voltages required for the signal system. The transformers are protected on the primary side by a fuse which is contained in a westinghouse plug cut-out, the 2,200-volt line being aerial. The secondary windings at signals are three in number. There are 169-volt windings with taps for 17.8 volts for feeding the local phase of the track relay; a tap for 55 volts to feed signal lamps; a track winding with taps so that various voltages are obtainable from 1 to 7.8 volts, a 55-volt winding which supplies energy for the local phase of track relays which is controlled over the line. A copper shield is placed between primary and secondary windings and connected to ground as in the case of the former installation.

Line transformers at track feed locations have a primary voltage of 2,200 and step down so as to make them available for 1 to 7.8 volts. Two secondary windings are employed so that either track may be fed from the one transformer. A

copper shield is placed between primary and secondary windings.

Impedence Bonds and Track Circuits.

See core reactance bonds, above. These track circuits are center fed, average length about 4,000 feet.

Track Relays.

The track relays are of the polyphase induction type, and are provided with four front contacts. The track circuit is center fed and track relays are at each end of the section. The track relay at the signal has its local phase energy controlled over a line through a point on the track relay at the outgoing end. The line is supplied with 50-volt energy, fed through a resistance unit so that the proper voltage may be had at the terminals of the track relay by using the variable taps on the resistance unit. The line phase control wire is taken through switch instruments applied to any switch which may be located in the block. The relay at the outgoing end of the section has the local winding fed from the 17.8 tap from 169-volt winding.

Signals.

The signals are of the 2-A type, each equipped with a 25-cycle, 169-volt commutator motor. The third or 90 degree position of the blade is controlled by energy for the motor, being fed over a line wire from the 45 degree position of the signal in advance. This line is controlled from a circuit controller. The hold clear arrangement is the same as that used on the L. I. R. R. between Woodside and Jamaica.

Relay Housing and Stub Posts.

All relays are housed in cast iron boxes on wooden shelves. A terminal and fuse board arranged at the bottom of the box for incoming and outgoing wires. Grid boxes and line transformers are mounted on a wooden stub post, upon which is also mounted the secondary fuse box which contains the fuses for the secondary bus line of 169 volts.

Circuits.

See Fig. 21.

Hudson & Manhattan.

The Hudson & Manhattan at the time of writing this report has in operation a little over 13 miles of single track tunnel. Operation over this line is controlled by 159 automatic block signals and 8 interlocking plants. The uptown division, or that portion of the line between Hoboken, N. J., and 23rd street, New York city, was opened for service on February 25, 1908. This portion embrances about 7 miles of single track tunnel; 101 automatic block signals, and 5 interlocking plants, all of the General Railway Signal Co.'s type. The down town section of the system, extending from Hoboken to the Church street terminal is signaled with the Union Switch & Signal Co.'s apparatus. The 6¼ miles of track is safeguarded by 58 automatic block signals and 3 interlocking plants. Within the year, it is expected to increase the mileage of the system by at least 3 miles.

All the apparatus used in the signal system is of a special design to meet the scant clearances existing in the tunnels. Automatic stops are used throughout and double rail return. The signals are laid out with a full block overlap, (we understood it was at least three blocks long—Editor), the headway in the rush hours being 90 seconds, and while the number of passengers carried does not yet begin to equal that on some other rapid transit systems. No other railroad in the country maintains, for a period of hours, such a schedule as that on the Hudson & Manhattan.

Power Supply.

Direct current at 600 volts is used for the operation of the trains, single phase alternating current at 25 cycles, 1,100 volts being supplied from the power house to the signal feeders. All current for use on the system is generated at the main power house in Jersey City, where 4 steam turbine generators produce current at 11,000 volts. Current is supplied to several sub-stations from the man power house for the proper distribution of the propulsion current. The entire signal system, however, is normally fed from the power house direct.

Signal Apparatus.

At each signal location, small oil-cooled transformers are placed, fed from the signal mains through a high-tension fuse box. These transformers supply current for the track circuits and also for the signal lighting and other local requirements.

For the purpose of simplification, the original or up-town installation, will be briefly described first. The transformers used with this apparatus supply current for the track, fed at from 1.15 volts to 10.4 volts as required for track circuits for different lengths and conditions. For signal lighting, 26 volts is used, while 11 volts and 19 volts are used for the relay phases, etc. The relays are the polyphase induction type described previously. Signal movements are of the shutter type, home and distant indication being given, 2 lamps, in multiple, constantly burning for each indication. The shutter is moved by a polyphase induction motor similar to that of the relay and passes between the lights and the lenses, thereby changing the indication from stop to clear, or vice versa. The signal movement is also in reality a line relay as 4 complete sets of contacts are provided through which various circuits are controlled. When first installed, the automatic stops were controlled by a 600-volt motor, these, however, have since been replaced by the pneumatic type. The reactance bonds used are of the core type and are essentially the same in both the up-town and the down-town systems. All track circuits are end fed.

The chief differences between the up-town and down-town installations are, that, in the latter, light signals are used, no movement being employed, no line relays are used and the electro-pneumatic track relay is that described in the section headed "Vane Type Electro Pneumatic." Transformers on this system also have two windings, from 1 to 6.5 volts being supplied for the track circuits, 55, 57½ and 60 volts being furnished for signal lighting etc. The relays and automatic stops are electro pneumatic, the latter being operated by an alternating current magnet controlling a pin valve.

(To be continued.)

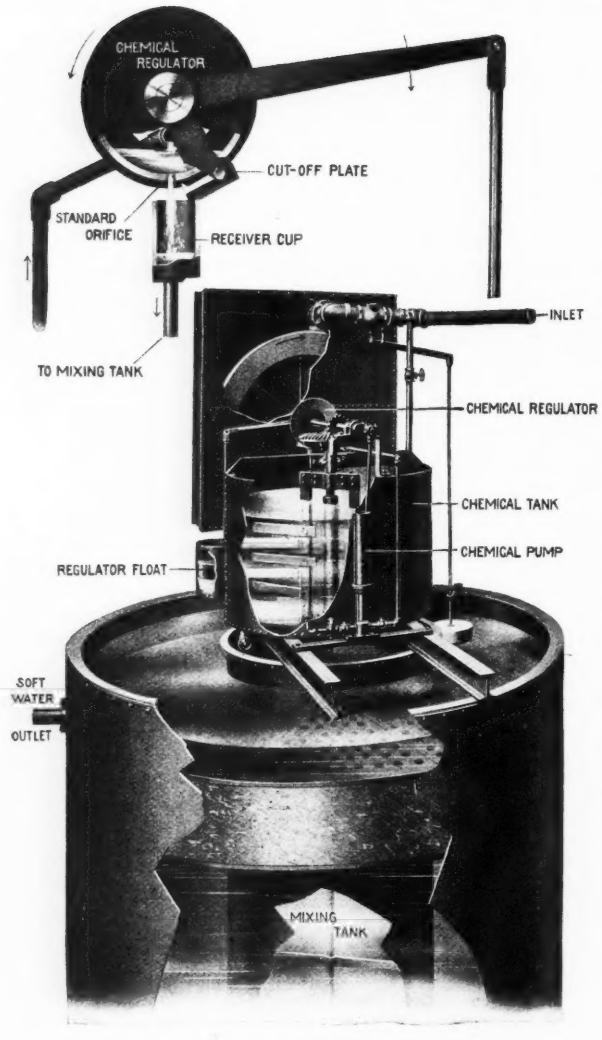
The Santa Fe will during 1911 instal automatic block signals on 45 miles of line. These will be upper-quadrant semaphores, three-position, normal clear, operating on alternating current. It is proposed to instal mechanical interlockings at Suwanee, N. M., Dennison, Ariz., and Cottonwood, Cal., where meeting points are to be arranged with lap sidings. In these plants the switches will be mechanically operated, but the signals will be worked by electric motors, taking current from primary batteries. Electric interlocking plants will be put in at Richfield, Cal., and Rio Puerco, N. M., 24 levers each. Electric interlocking plants of 36 levers each are now being built at Daggett and Fullerton, Cal. The signals at all of these plants will be upper-quadrant, three-position.

The Long Island will install automatic signals during this year on nine miles of double track.

It is expected that the New York, New Haven & Hartford during this year will install the block system on 137 miles of the road.

John Leisenring, signal engineer of the Hudson & Manhattan, at New York, has been appointed to the new position of signal engineer of the Illinois Traction System, with office at Peoria, Ill., effective Dec. 15.

With the Manufacturers



Booth Water Softener.

Type "G" Booth Water Softener.

Every feature essential for accurate treatment of water is said to be embodied in this water softener. Owing to the absence of the "ground-level-operation" feature of the Type "F" Booth Water Softener, the Type "G" is even simpler in construction. This type is constructed in sizes of 500 gallons hourly purifying capacity and upwards. The raw water entering the softener for purification flows through the balanced inlet float valve to the over-shot wheel, and so furnishes the power to drive the agitators in the chemical tank and the mixing tank. It is in this mixing tank, in which the direction of flow is downward, that the work of softening takes place. Chemicals, usually hydrated lime and soda ash, are dissolved in the chemical tank once for each twelve hours of operation. In some of the larger sizes a solution tank at the ground level is furnished for dissolving chemicals which can then be hoisted by a steam operated ejector or by similar means. From the chemical tank the solution is delivered to the rotary chemical regulator, a drum keyed to the water wheel shaft. The chemical pump delivers from the chemical tank into the regulator several times as much solution as is required by the water for treatment. The excess amount of solution flows out of the annular opening in the end of the regulator and returns to the chemical tank. It will thus be seen that the function of the pump is to maintain an overflow of solution in the regulator and that the pump itself has no direct control over the quantity of solution fed to the water. There is a standard orifice in the circumference of the chemical regulator and the rotation of the regulator causes the submergence of the orifice for 25 per cent of the time that the softener is in operation. The opening in the receiver cup is such that it catches just enough chemical from the orifice to treat correctly the water at the maximum rate of operation. The position of the regulator float is controlled by the water in the course of its flow from the water wheel into the top of the mixing tank, where the purifying solution meets the raw water. When the softener is operated at full capacity, the regulator float which actuates the cut-off crank carrying the cut-off plate, withdraws the latter so that the top of the receiver cap is uncovered to full extent. If the amount of water entering the softener lessens or stops, the regulator float assumes a lower position, shifting the cut-off plate, and thereby proportions the quantity of solution delivered to the receiver cup to the quantity of water passing into the softener. From the receiver cup the chemical solution flows by gravity to the mixing tank. Attention is called to the fact that the speed of rotation of the water wheel shaft is without effect on the amount of solution delivered into the receiver cup. For any given position of the cut-off plate the quantity of solution caught is the same during each minute of operation. A particularly desirable feature of the Type "G" chemical regulator is that no agitators are required to keep the solution which it contains thoroughly agitated at all times. The reason for this is that the chemical regulator drum itself rotates with the water wheel shaft. Another simple feature is the arrangement of cut-off plate and receiver cup, with respect to the drum of the regulator. None of these ever touches the other at the point of regulation, so that absolutely no friction or wear is possible. The L. M. Booth Co., New York and Chicago, are the makers.

The Shaw Continuous Blueprint Machine.

The operation of this machine is said by its makers to be remarkable for its simplicity, convenience and effectiveness. There is no unclamping of covers, no rewinding of apron, no rolling or unrolling. The "Shaw" operates by a single arc lamp, which uses 15 amperes at 110 volts, or 7½ amperes at 220 volts, traveling up and down continuously in the center of a half cylinder of glass, while the paper and tracing are carried around by an endless canvas band. All that is necessary is to insert the ends of the paper and the tracing between the guide rollers and the machine does the rest.

The feeding of the paper and the tracing, the traversing of the lamp across them, and the securing of the necessary contact between them is effected automatically. The even contact obtained by the patented tension device, and the regular exposure due to the constant travel of the work, results, it is claimed, in sharp, clear, effective prints of even tint, such as would require the most expert operator to produce on any ordinary electric copier. Being entirely automatic, and having no complicated adjustments, this machine can be operated by a boy or girl, therefore doing away with the expensive expert operator.

This machine will make a continuous print of any length, producing no unsightly joints. In making long prints, the paper is mounted on one roller and the tracing on another provided for that purpose and fed into the machine auto-

matically, while a driver roller at the opposite side of the machine collects both paper and tracings. Short prints are fed in one after another at one side of the machine and taken out at the opposite side. While one is being printed, another is coming out or being put in, and no time is lost by putting the prints in and taking them out.

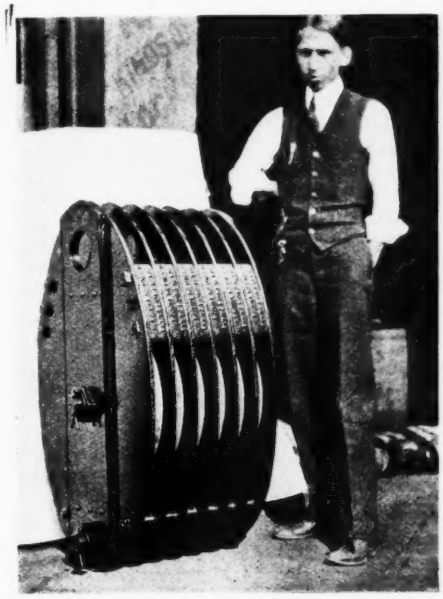
The printing speed of the 42-inch machine is 2 feet per minute, using rapid paper. This rate of speed adapts the machine to any chemical printing process and also to tracings of varying density. The speed is adjusted to suit any process by shifting the belt, which is on cone pulleys.

The Shaw machine requires only a space 2 feet 6 inches square and head-room of 8 feet, making it especially adapted for small offices where floor space has to be economized. The shipping weight is about 400 pounds. This machine is sold by the Frederick Post Co., Chicago, Ill.

A diary for 1911, just published by the Westinghouse Electric & Manufacturing Co., Pittsburg, Pa., describes briefly Westinghouse progress in a number of products, such as Cooper Hewitt electric lamps, gas and steam engines, electric locomotives, electric lamps. Useful data are given on these subjects, including tables on the resistance of wires, the heating value of some American coals, etc. The diary also contains miscellaneous information, such as the population of cities and the best hotels.

A Large Block.

We illustrate herewith a six-sheave block, which is one of two we just finished for the Seaboard Construction Co., of Philadelphia, Pa., by W. W. Patterson Co., of Pittsburg, Pa. They claim that this is the strongest and heaviest six-sheave



block ever made, the safe working load of the two blocks being 125 tons. These blocks were made especially strong, so that on the bottom of each six-sheave block could be attached a standard triple-sheave block, which would then give the same working effect as two nine-sheave blocks. This is a novel way to reave up blocks. This feature was made necessary by having a short mast and long boom, 20 ft. and 50 ft. respectively.

The blocks were for the topping lift of a large derrick car, which was built to handle 50 tons. All plates in blocks are ½ in. thick, side straps 8 in. by ¾ in., head bolt 4½ in., sheave pin 3 in., bottom bolt, to which was attached triple block, 2½ in., sheaves 20 in. diameter, metaline bushed and grooved for ⅞ in. plow steel cable, weight of each block 1,804 lbs. There were no shackles to the blocks, but they were attached to the car by 4½ in. head bolts. These two blocks were furnished in one week, which in itself is said to be a record time for such large blocks.

Railway Appliances Association.

The Railway Appliance Association will hold its annual exhibition of railway appliances used in the construction and maintenance of railways at the Coliseum, Chicago, March 20 to 25, inclusive, 1911. The exhibition will occupy the entire main floor, annex and balcony. Of the 49,000 sq. ft. devoted to exhibits, about 40,000 sq. ft. had been secured in December by the different exhibitors, leaving only 9,000 sq. ft. to be sold.

Among the extra attractions which have been secured and which will be shown in the balcony, is a model of Brennan's "Mono-Rail Car" in full operation.

Applications for space should be made to John N. Reynolds, secretary, 303 Dearborn street, Chicago.

Following is a list of the exhibitors who had secured space:

Adams Bros., Chicago.
Adams & Westlake Co., Chicago.
Ajax Forge Co., Chicago.
Alamo Manufacturing Co., Hillsdale, Mich.
Alexander Crossing Co., Clinton.
Allith Manufacturing Co., Chicago.
American Concrete Co., Chicago.
American Guard Rail & Fastener Co., Philadelphia, Pa.
American Hoist & Derrick Co., St. Paul, Minn.
American Nut & Bolt Fastener Co., Allegheny, Pa.
American Railway Signal Co., Cleveland, Ohio.
American Rolling Mill Co., Middletown, Ohio.
American Steel & Wire Co., Chicago.
American Valve & Meter Co., Cincinnati, Ohio.
American Vulcanized Fibre Co., Wilmington, Del.
American Well Works, Aurora, Ill.
Armspear Manufacturing Co., New York.
Asphalt Ready Roofing Co., New York.
Baird Electric Co., Chicago.
Barrett Manufacturing Co., New York.
Bausch & Lomb Optical Co., Rochester, N. Y.
Beaver Dam Malleable Iron Works, Beaver Dam, Wis.
Bosser, W. F., Manufacturing Co., Utica, N. Y.
Bowser, S. F., & Co., Ft. Wayne, Ind.
Bryant Zinc Co., Chicago.
Buda Company, Chicago.
Buyers Index Company, Chicago.
Cambria Steel Co., Johnstown, Pa.
Card & McArdle, Waukegan, Ill.
Carnegie Steel Co., Pittsburgh, Pa.
Carpenter, George B., & Co., Chicago.
Chicago Bridge & Iron Works, Chicago.
Chicago Steel Tape Co., Chicago.
Cleveland Frog & Crossing Co., Cleveland, Ohio.
Cook's Standard Tool Co., Kalamazoo, Mich.
D. & A. Post Mold Co., Three Rivers, Mich.
Detroit Graphite Co., Detroit, Mich.
Dickinson, Paul, Inc., Chicago.
Dietzgen, Eugene, Co., Chicago.
Dilworth, Porter & Co., Pittsburgh, Pa.
Dressel Railway Lamp Works, New York.
Duplex Metals Co., New York.
Eastern Granite Roofing Co., New York.
Economy Separable Switch Point Co., Louisville, Ky.
Edison Manufacturing Co., Orange, N. J.
Edison Storage Battery Co., Orange, N. J.
Electric Storage Battery Co., Philadelphia, Pa.
Fairbanks, Morse & Co., Chicago.
Federal Signal Co., Albany, N. Y.
Foster, Frank M., Columbus, Mo.
Franklin Manuafacturing Co. of Penna., Franklin, Pa.
General Electric Co., Schenectady, N. Y.
General Railway Signal Co., Rochester, N. Y.
Gifford-Wood Co., Hudson, N. Y.
Goheen Mannufacturing Co., Canton, Ohio.
Peter Gray & Sons, Boston, Mass.
Greenlee Bros. & Co., Rockford, Ill.
Grip Nut Company, Chicago.
Hall Signal Co., New York.
Handlan-Buck Manufacturing Co., St. Louis, Mo.
Harry Bros. Co., Newport, Ky.
The Hart Steel Co., Elyria, Ohio.
Hayes Track Appliance Co., Geneva, N. Y.
The Hobart Allfree Co., Chicago.
Hubbard & Co., Pittsburgh, Pa.
Hurley Track Laying Machine Co., Chicago.
Ideal Concrete Machinery Co., South Bend, Ind.
Indianapolis Switch & Frog Co., Springfield, Ohio.

Ingalls Shepard Forging Co., Chicago.
Interlocking Nut & Bolt Co., Pittsburgh, Pa.
Johns-Manville, H. W., Co., New York.
Jordan, O. F., Co., Chicago.
Joyce-Cridland Co., Dayton, Ohio.
Kalamazoo Railway Supply Co., Kalamazoo, Mich.
Kenly, W. K., Co., Chicago.
The Kennicott Co., Chicago Heights, Ill.
Kerite Insulated Wire & Cable Co., New York.
Kerlin Automatic Post Machine Co., Delphi, Ind.
Keuffel & Esser Co., New York.
Lackawanna Steel Co., Buffalo, N. Y.
Lehon Company, Chicago.
Lidgerwood Manufacturing Co., New York.
Link-Belt Co., Chicago.
Lorain Steel Co., Johnstown, Pa.
Fufkin Rule Co., Saginaw, Mich.
Lupton's, David, Sons Co., Philadelphia, Pa.
Luther Grinder Manufacturing Co., Milwaukee, Wis.
Lutz-Lockwood Manufacturing Co., Aldene, N. J.
Massey Co., C. F., Chicago.
Matthews & Bro., W. N., St. Louis, Mo.
Milburn, Alexander, Co., Baltimore, Md.
Morden Frog & Crossing Co., Chicago.
National Lock Washer Co., Newark, N. J.
National Malleable Castings Co., Chicago.
National Surface Guard Co., Chicago.
Nichols, Geo. P., & Bro., Chicago.
Okonite Co., New York.
Otto Gas Engine Works, Chicago.
Spencer Otis Co., Chicago.
P. & M. Co., Chicago.
Patterson Co., W. W., Pittsburgh, Pa.
Pease Co., C. F., Chicago.
Pennsylvania Steel Co., Steelton, Pa.
Pocket List of Railway Officials, New York.
Potter Winslow Co., Chicago.
Q. & C. Co., New York.
Rail Joint Co., New York.
Railroad Supply Co., Chicago.
Railway Age Gazette, New York.
Railway List Company, Chicago.
Railway and Engineering Review, Chicago.
Ramapo Iron Works, Hillburn, N. Y.
Manganese Steel Co., Hillburn, N. Y.
Roberts & Schaefer Co., Chicago.
Robinson, George M., Dubuque, Iowa.
Scherzer Rolling Lift Bridge Co., Chicago.
Sellers Manufacturing Co., Chicago.
Standard Asphalt & Rubber Co., Chicago.
Standard Paint Co., New York.
Templeton, Kenly Co., Chicago.
Union Switch & Signal Co., Swissvale, Pa.
U. S. Metal & Manufacturing Co., New York.
U. S. Wind Engine & Pump Co., Batavia, Ill.
Universal Metallic Tie Co., Salt Lake City, Utah.
Verona Tool Works, Pittsburgh, Pa.
Waterloo Cement Machinery Corporation, Waterloo, Iowa.
Weisell Nut Lock Co., Chicago.
Welsh, William M., Straight Scale Co., Denver, Colo.
Whall, C. H., & Co., Boston, Mass.
Wharton, Jr., William, & Co., Philadelphia, Pa.
Winan's Improved Rail Joint Co., Portland, Ore.

The Union Switch & Signal Co. has just issued the following bulletins, Nos. 50, 51, 52.

The first describes in great detail the new "Style T" signal. This is one of the top post signals which attracted such favorable attention at the Coliseum exhibit in connection with the last meeting of the Maintenance of Way Association.

The second bulletin deals with the "Automatic Electric Staff System." This is an adaptation of the well-known staff system, fitting it for use at stations where there are no attendants, the machines being operated by the train crews. The bulletin shows how this system is particularly applicable to single-track electric railways.

The third bulletin is a reprint of a recent editorial dealing with the train staff as above applied.

Wire Rope Protection.

As soon as a rope is put into service wear and corrision begin to act. Unless something is done to counteract these weakening agencies, the heavy expense of frequent renewals will follow. Wire rope is subjected to both internal and external wear. The first results from the rubbing of the strands and wires upon one another, the second is caused by the slipping and rubbing of the rope as it winds and unwinds about the drum and over the pulleys.

Corrosion results from exposure to moisture, gases and like corrosive influences. Often in mine service, acid or alkaline water reaches the rope and hastens its destruction.

To protect rope against both wear and corrision the Joseph Dixon Crucible Co., of Jersey City, has on the market a product called "Dixon's Waterproof Graphite Grease." Its makers claim for it a peculiar efficiency said to be due to the flake graphite in its composition, which beside being the best of solid lubricants, is entirely unaffected by moisture, atmosphere, gases, acids or alkalis.

Flake graphite is tenacious and coats the rope with a durable tough veneer that increases its life and prevents damage. "Dixon's Waterproof Graphite Grease," however, is said to do more than preserve the outside of the rope. It works into the innermost strands, minimizing internal friction and saving wear.

The Joseph Dixon Crucible Co. has just issued an attractive booklet of some forty pages which is devoted entirely to Dixon's line of products for railroads. This should be of interest to all those engaged in railroading. The title of the booklet is, "Graphite Products for the Railroad."

Trial of the Perry-Prentice Automatic Stop on the Canadian Pacific.

The Perry-Prentice wireless apparatus for operating a cab signal and for applying the brakes, has been fitted to locomotive No. 798 of the Canadian Pacific, and the apparatus was successfully tried, with a train of twelve freight cars, near Toronto on December 8. In this apparatus a coherer on the locomotive is actuated by Hertzian waves from a current flowing through a wire which is strung along the line of the road. In the Canadian Pacific experiments, this wire is laid in trunking on the ties between the rails, and the antenna connecting with the coherer is suspended beneath the engine, so as to be carried along about 6 in. above the trunking. The line of the Canadian Pacific between North Parkdale and West Toronto has been equipped with six block sections, each about half a mile long, and the circuit (alternating current) in the wire in the trunking which is used for actuating the stop is controlled by the track relays of the block sections in a manner similar to that used to control distant signals. The wire in the trunking extends throughout the length of the road signaled, and is arranged normally to hold the cab apparatus in the proceed position; and the stop or caution indication is produced by opening the circuit. The apparatus in the cab is arranged so that the first effect of a caution signal is to sound a whistle; and the automatic application of the brakes does not take place until three seconds after the sound of the whistle.

Railway Business Association.

TERM EXPIRING 1911:

W. E. Clow, Chicago, Ill.; Pres., James B. Clow & Sons.
E. B. Leigh, Chicago, Ill.; Pres., Chicago Ry. Equipment Co.
James Viles, Chicago, Ill.; Pres., The Buda Company.
A. M. Kittredge, Dayton, Ohio; Pres., Barney & Smith Car Co.
W. H. Whiteside, Milwaukee, Wis.; Pres., Allis-Chalmers Co.
J. H. Schwacke, Philadelphia, Pa.; William Sellers & Co., Inc.

TERM EXPIRING 1912:

H. G. Prout, Swissvale Pa.; V. P., Union Switch & Signal Co.
W. B. Leach, Boston, Mass.; G. M. & Treas., Hunt-Spiller Manfg. Corpn.
J. S. Coffin, New York; Pres., Franklin Ry. Supply Co.
E. L. Adreon, St. Louis; V. P., American Brake Co.
Alba B. Johnson, Philadelphia; V. P., Baldwin Locomotive Works.
Walter H. Cottingham, Cleveland; Pres., Sherwin-Williams Co.

TERM EXPIRING 1913:

William C. Dodd, Newark, N. J.; Pres., National Lock Washer Co.
Henry Elliot, East St. Louis, Ill.; Pres., Elliot Frog & Switch Co.
W. H. Miner, Chicago; Pres., W. H. Miner Co.
Rudolph Ortmann, Chicago; Pres., Ajax Forge Co.
W. G. Pearce, New York; V. P., Edgar Allen Amer. Manganese Steel Co.
W. P. Worth, Coatesville, Pa.; Treas., Worth Brothers Co.

The general executive committee of the association con-

sists of the elective officers, chosen annually (president, vice-presidents and treasurer), and the 18 executive members.

Effective January 1, the lines of the Rock Island system were divided into two ground divisions for purpose of operation, as follows: Lines north of Caldwell, Kan., in charge of W. S. Tinsman, formerly general manager of the Chicago, Rock Island & Pacific, with office at Chicago. W. M. Whitenton, vice-president and general manager of the Chicago, Rock Island & Gulf, at Fort Worth, Tex., has been appointed general manager of the lines south of Caldwell, with office at Fort Worth. Both these officers report to F. O. Melcher, second vice-president, Chicago.

LOCOMOTIVE ASH PANS.*

Report of George L. Fowler, Consulting Mechanical Engineer.

The drawings furnished by the several railroad companies, showing designs of ash pans in use on their respective roads, have been examined with special reference to their applicability as fulfilling the requirements of law, namely, that on and after January 1, 1910, locomotives shall be equipped with ash pans that may be cleaned or emptied without making it necessary for a man to go beneath the engine or between the rails in order to do the work required.

In considering this matter there are two points of view that may be taken—one is that of a strict literal interpretation of the law and the other that of the spirit. It is evident that the intention of its framers was to construct a statute to protect workmen from personal injury while engaged in the occupation of dumping and cleaning the ash pans of locomotive engines. That this might be accomplished it was enacted that ash pans must be used on locomotives moving interstate traffic that can be dumped and cleaned without making it necessary for the man to go between the rails or beneath the engine. To anyone familiar with mechanisms of this character it is evident that they must be of a very substantial construction, simple in design, not apt to get out of order because of the stresses or heat to which they might be subject, and finally be easy to manipulate and not liable to clogging and sticking either by ashes or ice. Of all these requirements strength of construction and simplicity of design are the most easily met, but it is quite possible that, in two designs that are nearly identical, one may be very efficient and the other impracticable.

For example, where a simple slide is used to close a hopper pan: If one has free guideways from which the ashes are easily pushed and the other has a pocket or a closed end, the first may work year in and year out without causing trouble and the other be jammed at every operation. So in the matter of warping plates; if these are not made of suitable metal, properly ribbed and strengthened, the heat of the ashes will distort them and cause them to bind. Finally, it was the undoubted intention of the framers of the law to require that all of the work of dumping and cleaning the ash pans and putting the engine back in working order should be done without the necessity of going between the rails or beneath the machine. If, then, an ash pan can be dumped and cleaned as required, while yet its parts can not be replaced without requiring that a man should go between the rails, it may fulfill the letter of the law, but it fails to meet its spirit and intention. Nor should a satisfactory ash pan be liable to frequent failure and disablement. It may be stated, then, that the requirements of a pan suitable for this work are that it should be strong, simple, easily manipulated and not liable to get out of order from load, manipulation, or heat; and not the least of the requirements is that it should not be liable to freeze shut.

It is not thought to be necessary to criticise the designs in the light of an ideal pan, but rather to regard them solely on the basis as to whether they fulfill, when in good order, the simple requirements of the law; and it is as such that they will be considered.

*From the report of the Block Signal and Train Control Board.

Speaking broadly, there are two general types of ash pans in use on American locomotives, the hopper bottom and the shallow, flat pan. The latter is almost wholly confined to old and light locomotives where fire boxes are low and between the frames, whereas the hopper type is in use on all locomotives where the foundation ring of the fire box is placed on top of the frames, and where the length of the fire box is greater than the distance between the axles over which it stands.

Shallow Pans.

As for the so-called shallow pans, a number of arrangements are presented that make cleaning from the cab or the side of the tracks possible. These may be classified as the blower, drop bottom, slide, and side cleaning.

Of these the blower method appears to be the most extensively used. It is an application of a series of steam jets across one end, with nozzles so directed as to blow the contents of pan out at the other end. It is effective and can be made to clear the pan completely. Examples of the use of this type of pan are to be found on the Chicago, Milwaukee & St. Paul; the Wabash; the Minneapolis, St. Paul & Sault Ste. Marie; the Seaboard Air Line; the Chicago Great Western; the Duluth & Iron Range; the Wheeling & Lake Erie; the Elgin, Joliet & Eastern; the Duluth, Missabe & Northern, and Colorado & Southern railways. In one case, that of the Duluth, Missabe & Northern, the jets are in two series; there is a shallow pan which extends over the top of an axle, and then drops down to a deep section back of the axle. Here there is a row of blowers at the front end of the shallow section, the steam from which drives the ashes into the deep section at the rear, from which they are ejected by a similar set of jets.

Of the drop-bottom type there are two varieties, the slat and the drop door. The slat is represented by the shallow pans of the Chesapeake & Ohio and the Chicago & Eastern Illinois. In the former there are a series of cast slats extending across and forming the bottom of the ash pan. They are pivoted on their center line and are moved by a rod connected to each one in exactly the same manner as an ordinary window blind. In the ash pans of the Chicago & Eastern Illinois this is modified by the introduction of a series of dead plates that alternate with the movable slats. These dead plates have upper surfaces that are inclined, so that when the space covered by the movable slats is opened the ashes will slide out and fall to the ground. Another form of drop bottom is that of the Pennsylvania Lines West, where there are two plates that are hinged on bars extending the length of the fire box on either side, and which come together on the center line. By turning the bars, the plates may be swung down out of the way. In the case under consideration this is done by a man at the side of the track, who works a lever by which the flaps are opened or closed.

The slide method of closing the shallow pan is used on the engines of the Missouri Pacific. As it is evidently impracticable to use a slide whose surface is equal to the area of the whole bottom of the pan, the bottom is divided into two small, shallow hoppers, each of which is closed by a slide, and these two are connected so as to be operated by a system of levers. These levers are not shown in the Missouri Pacific drawings; without them the design does not comply with the requirements of the law.

The last method is that of having sliding doors in the vertical side sheets of the ash pan. With these it is necessary for the workman to draw the ashes out by hand, which he can readily do from one side of the track. Such a pan is illustrated in that of the New York, New Haven & Hartford. It is the simplest of any construction, and while provision is made for cleaning from the sides, it is also possible that the men may assume the risk of going beneath the engine to do the work.

Hopper Pans.

Of the means for cleaning hopper-bottom pans, the sliding and the swinging door are the two classes in use.

The sliding door ordinarily consists of a simple flat slide

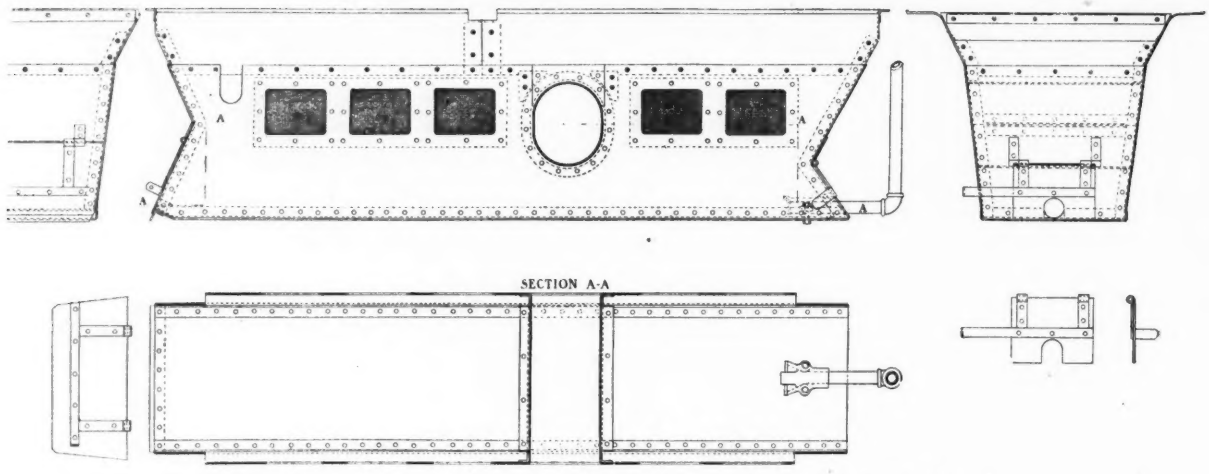


Fig. 20. Shallow Ash Pan, E. J. & E., Illustrating Method of Cleaning with Steam Jet.

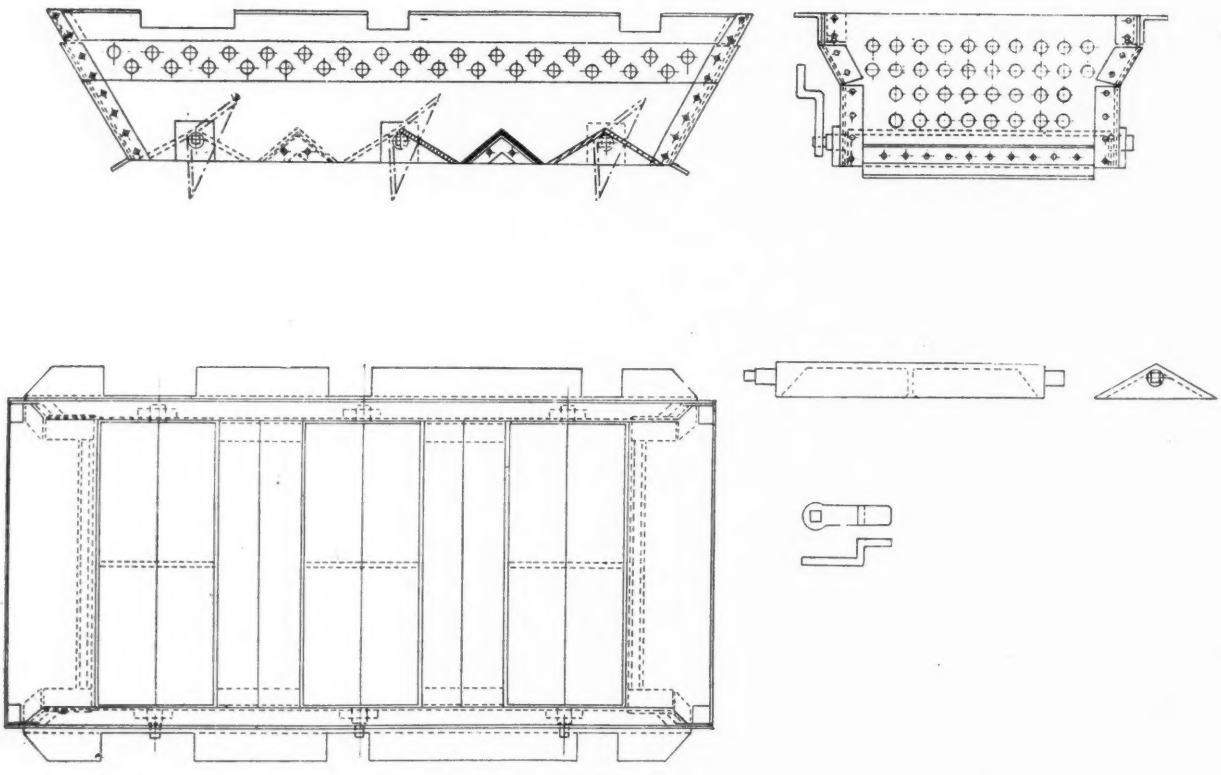


Fig. 21. Shallow Ash Pan, E. J. & E., Illustrating Use of Slats to Form Bottom.

moving horizontally. When it is worked from the cab, its line of motion is usually parallel to the longitudinal axis of the engine. When operated independently, the slides have a transverse motion and are worked from one side of the track.

The most common form of hopper bottom is that having a slide with a longitudinal motion, the slides of the several hoppers being connected together so as to be operated in unison. This arrangement is shown in the drawings furnished by the Chesapeake & Ohio, the Chicago, Rock Island & Pacific; the Chicago, St. Paul, Minneapolis & Omaha; the Colorado & Southern; the Delaware, Lackawanna & Western; the Denver & Rio Grande; the Kansas City Southern; the Maine Central; the Missouri Pacific; the Minneapolis, St. Paul & Sault Ste. Marie; the Richmond, Fredericksburg & Potomac; the Seaboard Air Line, and the Wisconsin Central railways. On the drawings sent by the Missouri Pacific and the Chicago, Rock

Island & Pacific no means of operating these slides is shown other than by going beneath the engines. It is assumed, however, that such provisions have been made on the engines themselves.

While this method of operating ash pans will work satisfactorily when the parts are in good condition, it may happen that a jamming of the ashes in the clearance spaces will so bind upon the slides that they can not be moved with the ordinary means provided. Under such conditions the usual method is to go beneath the engine and jar the slides loose with a hammer. With this exception the arrangement fully complies with the requirements of the law.

A modification of the plain flat slide, but operated in the same manner as that already described, is one in use on the St. Louis & San Francisco. Instead of the flat plate there are

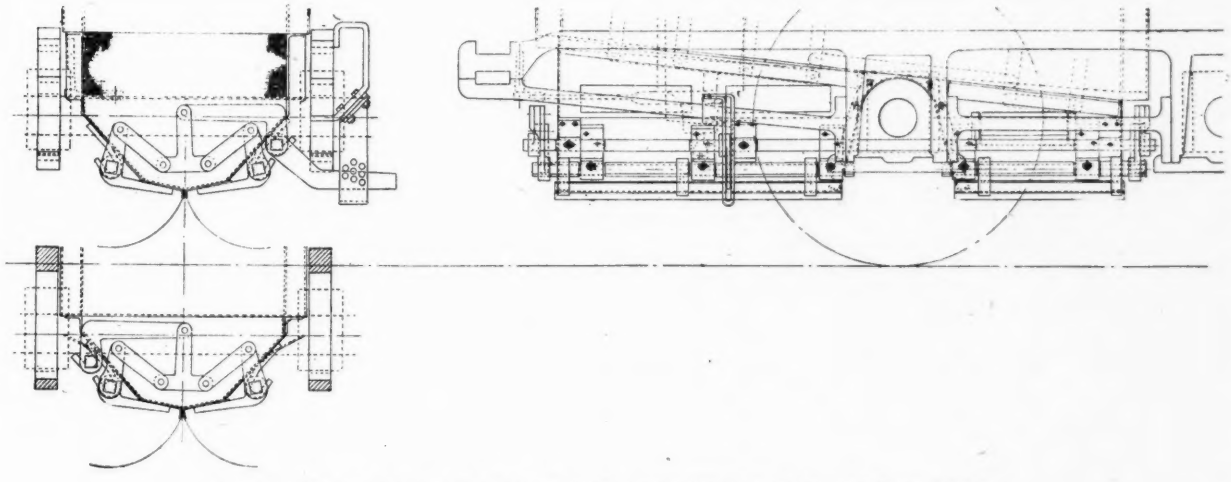


Fig. 22. Shallow Ash Pan, Penn. Lines West, Illustrating Use of Swinging Drop Bottom.

pans that slip beneath the mouths of the hoppers. When these are removed the ashes above fall to the ground; but no means is shown for cleaning the pans themselves without working beneath the engine, and no means is shown for operating the pans themselves. This plan can not, therefore, be approved until further drawings are provided showing the method of operation. It is known as "Anderson's locomotive ash pan."

For simplicity of construction the plain slide, moving laterally and worked by hand from the side of the track direct, and as used on the New York, New Haven & Hartford, takes the lead. These slides are pulled out on either side of the engine and after the ashes have fallen out they are replaced.

As to whether this design meets the law will depend upon the interpretation which may be put upon the law in the light of the question already referred to. In this case the hopper extends 9 ins. on each side of the center line of the tracks, or to a point 19¼ ins. inside the rails. In order to place this slide back in position after it has been withdrawn, the man must have at least a portion of his body from 14 to 17 ins. between the rails and probably the whole of it beneath projecting portions of the locomotive. But the hopper can be cleaned without going beneath the engine or between the rails.

Closely allied to the simple flat slide is one that is curved and moves through the arc of a circle. As constructed in the designs submitted to the board, it is an adaptation to the ash pan of the well-known cinder hopper or chute used on smoke boxes. In it the slide is carried on a pin which sustains the whole of the load, holds the mechanism in place, and serves as a pivot about which it turns. It is operated from the side of the engine, as on the engines of the Buffalo, Rochester & Pittsburg, or by a steam or air cylinder, as on those of the Chicago & Eastern Illinois. Both of these fully comply with the requirements of the law.

Of the swinging doors there are two general types in use. One is a simple flap, hinged at one edge and held and moved at the other by the operating mechanism. The other may be one of various modifications of a flat door pivoted at or near the center. Examples of the first-mentioned type are to be found in drawings submitted by the Chicago Great Western, the Chicago, Rock Island & Pacific, and the Wabash railways. In all of these the operating mechanism is manipulated from the side of the engine, outside the rails. The Chesapeake & Ohio presents a combination of the slide and flap in an engine with three hoppers, two of which are closed by a flat slide and one by the swinging flap, all being connected together and operated by a single lever located well outside the rails.

A modification of this arrangement is shown in the case of the Pennsylvania Lines West, where identically the same arrangement is used for hopper-bottom pans as for the shallow pans already described, with suitable changes of dimensions and of detailed arrangement of the parts.

In a number of designs presented the doors are arranged to be swung out of the way and clear of the hopper. They are carried by swinging hangers and are usually directly supported on trunnions cast directly on the plates themselves. Examples of such doors are presented in the drawings of the Wabash; the Chicago, Milwaukee & St. Paul; the New York Central & Hudson River; the Lake Shore & Michigan Southern; the Wheeling & Lake Erie; and the New York, Ontario & Western railways. In all of these the doors are both opened and closed from the cab or the side of the track, and therefore fully comply with the law. In some the operating mechanism is complicated, as in the case of the Wabash and the New York Central, though in most it is very simple. The general scheme, however, is to support the plate that closes the hoppers by trunnions by means of swinging hangers, and in letting out ashes to push the plate out of the way. These hangers all stand at an angle when the door is closed, so that, as it approaches the closed position, it has an upward increment of motion. This is shown in its simplest form in the ash pan of the Wheeling & Lake Erie.

Of all those shown, probably the most efficient is that used on the New York, Ontario & Western; the Lake Shore & Michigan Southern; and the Cincinnati, Hamilton & Dayton. In this there are two trunnions on the side of the plate. To the forward one the supporting hangers are pivoted, and to the back one the connection to the operating rod. The latter is worked from the cab. On the first motion of opening, the inclined hangers cause the plate to drop away from the hopper, thus it is at once freed from any clogging of ashes or resistance of ice. As the plate moves forward the ashes drop off and are pushed to the back. This overloads the rear portion, which thus tends to tilt down. This tendency is accentuated by

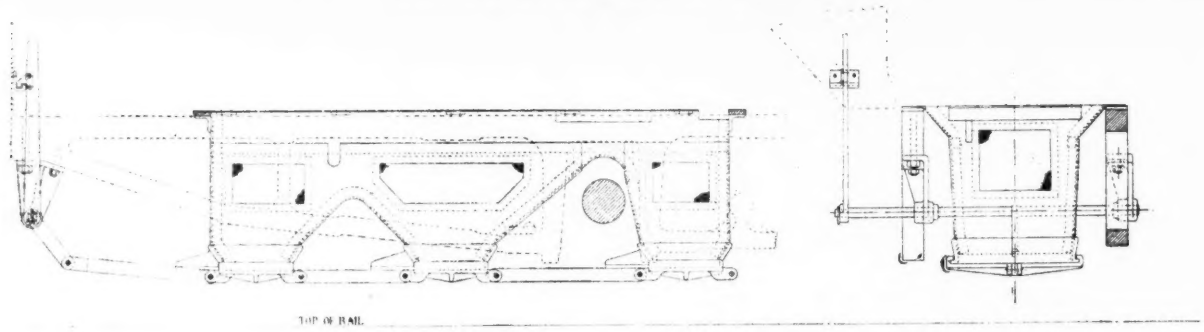


Fig. 23. Hopper Ash Pan, R. F. & P., Illustrating Use of Slide in Bottom

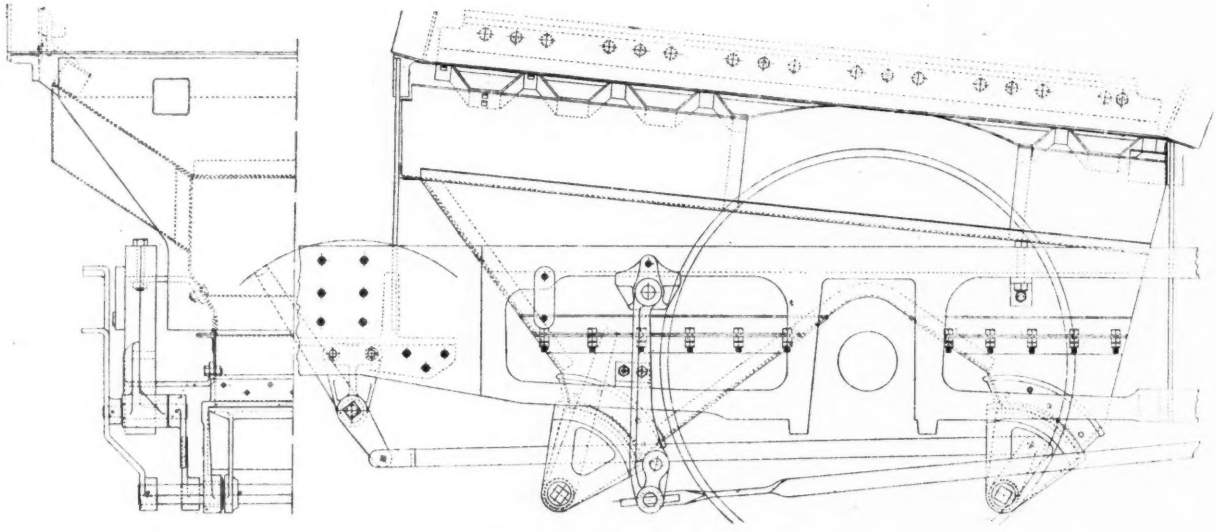


Fig. 27. Hopper Ash Pan, B. R. & P., Illustrating Circular Slide.

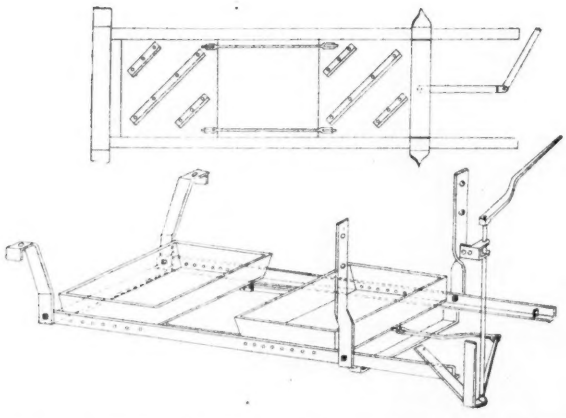


Fig. 25. Hopper Ash Pan, Frisco, Showing Use of Pan Slides.

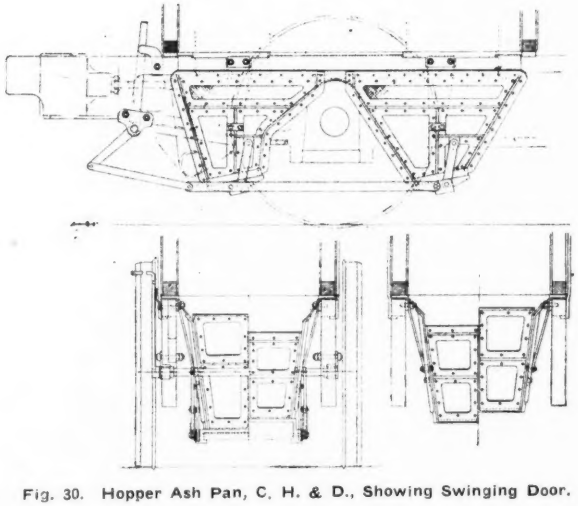


Fig. 30. Hopper Ash Pan, C. H. & D., Showing Swinging Door.

the thrust of the connecting bar, with the result that the plate is cocked to a sharp angle and swings up behind the hopper with a forward movement of the bar of but about one-half the width of the opening. In closing, the pull on the bar tends to draw the plate into a horizontal position. This device was patented and was first used on the New York, Ontario & Western, where it was known as the "Beals ash pan." The patent has, however, long since expired and it is free for common use.

REVIEW.

It will be seen, then, that so far as general design goes all of these ash pans fulfill the requirements of the law, with the possible exception of the one having transverse slides on the

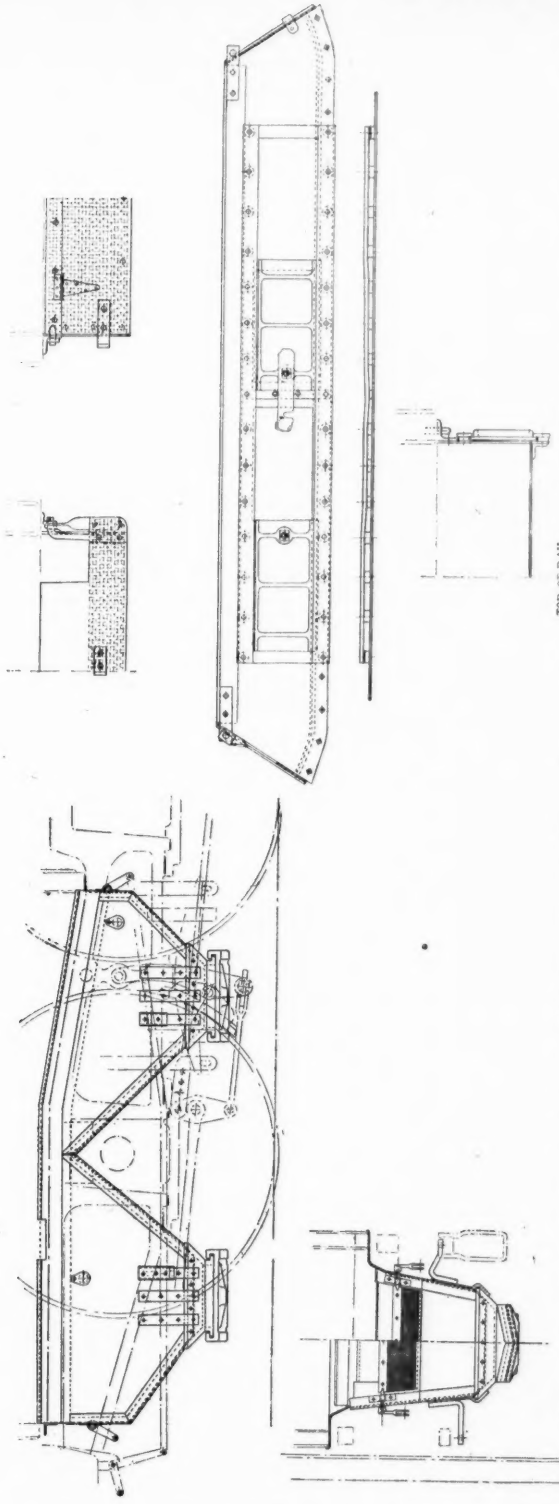


Fig. 26. Hopper Ash Pan, N. Y. N. H. & H., Showing Use of Lateral Slides Fig. 24. Shallow Ash Pan, N. Y. N. H. & H., Showing Openings in Vertical Slides.

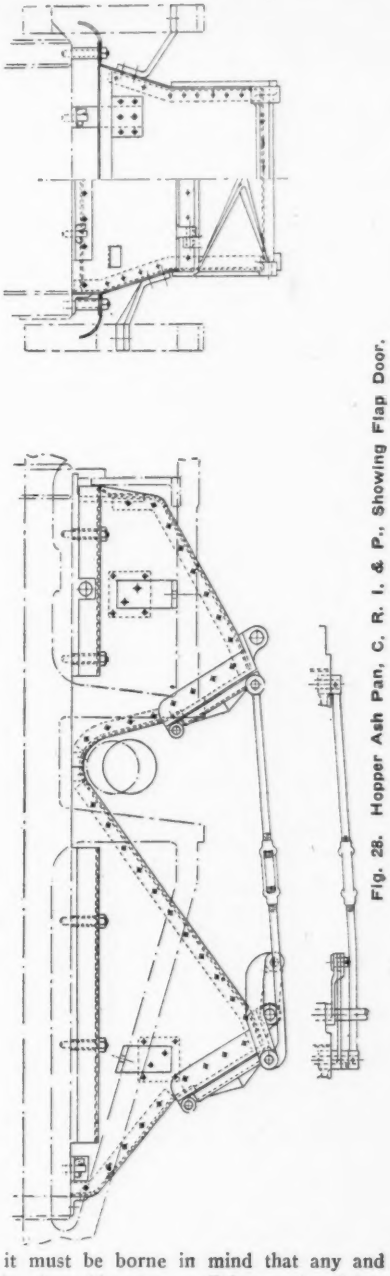


Fig. 28. Hopper Ash Pan, C. R. I. & P., Showing Flap Door.

New York, New Haven & Hartford and those in which no operating mechanism is shown, as noted. As to whether all of these slide pans, however, will operate under the severe conditions of frost and snow to which they may be subjected will remain for the inspectors of the board to ascertain, so that a final approval for their use should not be given until this is known to be the case.

In considering the relative merits of the pans that have been passed under review it must be borne in mind that any and all of them are capable of working in an efficient and satisfactory manner when they are in good condition. Speaking purely from personal experience and observation, I have found that the pan with a swinging bottom is much less likely to become disarranged than one with a sliding bottom. The latter is much more liable to become clogged with ashes or frozen shut than the swinging bottom.

If a sliding bottom pan, like that shown in the photograph of the Richmond, Fredericksburg & Potomac, becomes frozen it will be exceedingly difficult to jar it loose without going beneath the engine. The ice may be cracked, but it will jam and prevent the movement of the slide; so that, in order to insure a freedom from this trouble, some means of thawing out must be provided; this is done on some roads.

On the other hand, the swinging door whose first movement is away from its seat on the frame, is not apt to be held by the ice, or if it is, a blow on the side of the pan will crack such ice and allow the door to drop away at once.

In general, then, the swinging door as represented in the illustrations of the ash pans of the Pennsylvania Lines West, the Chicago, Rock Island & Pacific, and the New York, Ontario & Western are to be preferred.

Of course, where the sliding door is used in a warm climate the danger of freezing does not exist and the precaution which would have to be taken in more northern latitudes would be unnecessary.

The drawings accompanying this report may be taken as typical of all that have been discussed.

CONCLUSIONS.

The situation, as it appears to me, is as follows:

For some time the builders and railroad companies have been applying ash pans to locomotives that are considered to meet the requirements of the law.

Some of these would hardly be accepted except under a liberal interpretation.

Some will work well under favorable conditions, but are liable to disarrangement and clogging.

Some will work under all conditions and rarely fail.

The designs submitted by the railroads may be grouped under (1) those using rotating slats, (2) slides, (3) steam blowers, (4) flap doors and (5) swinging doors.

For shallow pans the steam blower and the flap door, as on the Pennsylvania Lines West, are to be recommended as the most efficient.

For hopper pans I should place in order of excellence, dependability and efficiency, first, the swinging door (New York, Ontario & Western); second, the flap door (Pennsylvania Lines West and Chicago, Rock Island & Pacific); third, the horizontal slide (Richmond, Fredericksburg & Potomac), all of which are illustrated.

Where the horizontal slide is used it will be advisable to provide means for thawing in cold climates.

Other types may be considered efficient, but to an inferior degree. Geo. L. Fowler.

CAR WHEELS REVOLVING INDEPENDENTLY OF THE AXLE.

Report by George L. Fowler.

The first car wheels were undoubtedly loose upon their axles; that is to say, the two wheels on the same axle could turn independently of each other. This arrangement was evidently unsatisfactory, for the custom was changed at an early date to the use of wheels rigidly attached to the axle and therefore revolving with it. This was the condition of affairs in 1870, which may be called the date of the advent of the present system of rolling-stock construction and operation.

The loose wheel had been advocated from time to time up to this date, but the efforts to introduce it had been spasmodic, and was soon abandoned; so that it was really not until the decade from 1870 to 1880 that a systematic and determined attempt was made to develop a loose wheel for railway car purposes.

Attempts were made by several persons during this period to develop such a wheel. The underlying reason for these attempts was that, as the outside rail of a curve of a railroad track is longer than the inner rail, and as wheels of the same diameter are forced to roll around these curves in the same number of revolutions, it is evident that one or the other of these wheels must slip upon the rail. To cause this slipping a considerable amount of power must be expended, and if it can be avoided, just that much less power will be required of the locomotive.

The basic idea of most of the early attempts had been that of putting the wheels rigidly upon an axle, cutting the latter in two in the middle, and then coupling the two parts together so that they could revolve independently of each other. And the reason for the failure lay, not so much in the weakness of the method of fastening, or the failure to act in service, but

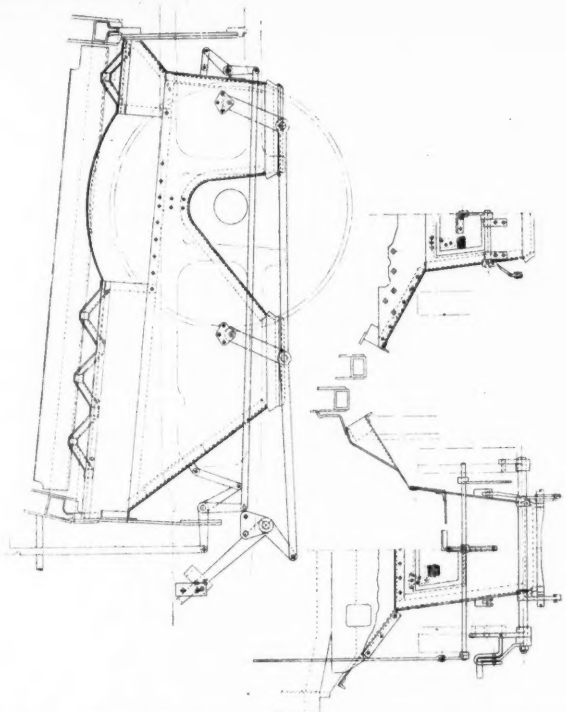


Fig. 29. Hopper Ash Pan, W. & L. E., Showing Swinging Door.

because of the inherent defect in the principle itself, as will be explained later in discussing the operation and failure of an axle of this sort in detail. Examples of this type of axle are shown in the patent office illustrations of the designs of Richard Vose (1856), J. K. Nelson (1868), D. B. Hunt (1869), S. S. Hickok (1872), W. W. Towson and B. T. Babbitt (1877), and Jones and G. W. Millington (1878). These few patents, which have been taken to illustrate the general trend of these inventions, may be divided into two classes: Those that attempted to hold the ends of the axles rigidly in line, while still permitting them to rotate independently, and those wherein an effort was made to allow the axle to bend under the load and thus accommodate itself to the conditions of service. Of the rigid type, the Vose, Nelson, Hunt, Babbitt, Jones and Millington are examples. These were, for the most part, the earlier patents, and were followed by those of Hickok and Towson, in which an attempt was made to permit a bending movement of the axle under load.

I have not considered myself warranted in looking up the records of the tests of those wheels and axles in detail, other than to be able to state that the trials were not satisfactory nor the results commensurate with the extra expense involved in the construction. This having been settled, the next move was that of placing one wheel loose on a rigid axle. Examples of this class of design are shown in the patents of S. & S. L. Hall (1876), Watkeys (1878-79), Baker and Spaulding (1878), and Sproull (1879). This design is a recurrence to the primitive type of wagon wheel with modifications of detail, the object of which was to permit the bending of the axle and, at the same time, permit the wheel to accommodate itself to such a fixture. None of these axles had more than a sporadic trial and no sustained attempt was made to make them a success. The owners were evidently discouraged as the result of the first trials and withdrew. This can be definitely stated to have been the case with Vose, Watkeys, Baker, and Babbitt, all of whom made tests that were failures.

A modification of the loose wheel is to be found in the use of a long sleeve. This first appears in the Vose patent (1856), and is also seen in that of Wells (1877), but finds its fullest exemplification in the patents of George W. Miltimore covering the

period from 1871 to 1879, and who can be credited with having made the most persistent and successful attempt to design a loose or independent wheel for railway car purposes of all who have tried it. He was backed by ample capital and his attempt will be followed in some detail.

Miltimore's first patent was issued to him, in connection with Ellis Doty, in 1871, and was based upon a new idea in car-wheel construction. Instead of cutting his axle in two, he made it rigid from end to end and did not allow it to revolve, but keyed it to his axle boxes. On the outside of this he placed a rotating sleeve extending from one axle box to the other, and on the outside of this he placed loose wheels. In operation upon a straight track the wheels would remain stationary upon the sleeve and the latter would revolve on the axle. This because of the difference in the diameter of the bearings, the greater diamter of the outer causing it to hold while the turning was done on the inside or smaller one.

The first work with this axle was done on the Chicago, Burlington & Quincy Railroad, and I believe his first wheels were built in the shops of that company.

The sleeve upon which the wheels themselves were mounted was of cast iron and was exceedingly heavy, weighing about 400 pounds for each pair, and it must be borne in mind that this was for cars of 10 tons capacity. A number of runs were made with a car so equipped, and the results were so seemingly satisfactory that a stock company was organized and a passenger car equipped for demonstrating purposes, though it was recognized at the time that a great reduction in weight would be required in order that it might be made commercially successful. But in the short distances operated and the light loads carried the mechanical defects which afterwards appeared had not developed.

This exhibition car was taken east to Boston, and it so happened that on the run from Albany to Boston, over the Boston & Albany Railroad, a Mr. Dow Canfield was on the train and, noticing the peculiar appearance of the wheels, entered the car to inquire about it. Mr. Canfield was an officer of the Arlington Car Manufacturing Company, of Arlington, Vt., and as the axle company was looking for a place in the east at which the axles could be made and which would serve as headquarters, an arrangement was made with Mr. Canfield; and from that time on all of the work of the Miltimore Car Axle Company was done at Arlington. This was in 1872. From that time for the next seven years the work of development and experiment was energetically pushed. The first work was done on the Rutland & Bennington Railroad, where a freight car was equipped with a set of these wheels and axles and it was found to ride very evenly and smoothly, but nothing was done in the way of a service application to determine the wearing qualities of the device, nor were any experiments made in this country to ascertain as to just what saving in resistance was effected by the loose wheel. Then, in addition to the box car on the Bennington & Rutland, a four-wheeled caboose was equipped on the Boston & Albany, and this was run over various sections of the road in regular service.

The construction according to the first patent (No. 119831) was too crude to form an operable mechanism, as the spring or bending of the axle and the failure of lubrication to reach the moving parts caused the bearings to cut and the wheels to stick. This was quickly modified and the original simplicity done away with by the development of the construction shown in patent No. 133790, and this was the design that was placed upon the passenger car, already referred to, and brought east in 1873. In this there was a rigid axle of uniform diameter from end to end surrounded by a heavy cast-iron sleeve. This sleeve was fitted with brass bushings for bearings pressed in at each end which acted on the journal of the axle. This was a hardened pad fastened in the proper place and with a radius of curvature equal to that of the brass. The wheels were loose on the sleeve and were held in place by the journal box.

Lubrication was effected by filling the pockets at the ends of the sleeve with oil through the filling plugs just inside the wheel, and also by putting in oil through a hole drilled diagonally from the end of the axle. This hole was plugged at the outer end, and the oil poured in as required.

This construction worked efficiently and well on the first trials, the wheels running cool and apparently performing the functions for which they were designed.

The criticism that was made of the design was that it was complicated and the parts were inaccessible.

But in spite of the fact that the early trials showed good results, weaknesses and defects were soon developed, and these were for the most part of exactly the same character as those which had caused the failure and condemnation of designs based on the divided-axle principle. This was the fact that when any car axle is supported by its wheels and is loaded upon the projecting ends or journals outside the wheels, these ends will be caused to drop or hang down, the central part of the axle will be bowed up in the middle, and the wheels will be spread farther apart at the top than at the bottom. This and lubrication troubles were the things with which Miltimore had to contend, though the springing of the axle was the more serious of the two.

Occasional and repeated failures to lubricate with the design shown in patent No. 133790 simply caused the wheels to stick on the sleeve, for the most part, under which circumstances they acted merely as rigid wheels on an axle. But the springing up of the interior axle caused an excessive pressure to be put on the outer end of brass bushing in the sleeve and thus quickly wore it away into a bell shape. These were the troubles that developed on the Boston & Albany and Bennington & Rutland.

Incidentally Miltimore took out two patents (144347, of 1873, and 151543, of 1874), at this period relating to devices for varying the gauge of the wheels and for cushioning the side blow or lateral thrust, neither of which was ever tried.

The serious matter was the spring of the axle.

Miltimore was not a mechanic, nor even an educated man, but was merely fertile in resources. He therefroe failed to appreciate for several years the actual conditions. He did not have the reasoning or analytic faculty sufficiently developed to discover what was happening, and so jumped to the conclusion that the reason why the brass bushings wore out was that they were insufficiently lubricated; and so he turned his attention to the solving of the problem of lubrication and ignored the mechanical feature that lay at the root of his trouble. Hence we see that in 1874 he took out a patent that dealt solely with the problem of lubrication, and its application was as complete a failure as that which had gone before.

But soon after this date, in applying this design he learned of the spring of the axle, and attempted to overcome it by making it abnormally thick in the center. This merely aggravated the difficulty, as the sudden change in axle diameter just back of the wheel seat caused the whole deflection to be concentrated at that point, and the wear on the bushings was worse than ever.

He then took the first step to strike at the real trouble, and that after five years of constant and unremitting work. In his patent No. 171835, of 1876, he shows a brass bushing in the sleeve held by a wooden collar or wedge. The object of this was to permit the brass to yield and accommodate itself to the bend in the axle. This might have proven efficient had the axle been revolving and the bushing stationary, but when the reverse obtained the wood lost its elasticity at once, the bushing became loose and conditions were worse than ever.

However, matters had progressed so far that in 1875 Mr. Canfield was sent to England and Denmark to attempt the exploitation. Nothing was done in Denmark, but in England a four-wheeled car was equipped, and the only running or resistance tests in the history of the work were made. As no dynamometer car was available, these tests consisted in merely letting this car run down a grade at known speeds over curves of

different lengths and noting the distance required to stop, as compared with that of a similar car fitted with rigid wheels and axles. In every case the car with the loose wheels showed its resistance to be the less, because of the greater distance it would run before coming to rest. As to just what the actual difference was in this resistance there is no means of knowing, as the records are not available.

The next year, 1876, the company equipped its first trains for regular commercial service. These trains were operated on the narrow-gauge intramural railway at the Centennial Exposition in Philadelphia. Here there was a chance to develop the real weakness of the design, and it was done. There was constant and unending trouble with the lubrication, and the wear on the bushings referred to were very rapid. But the experience gained was utilized as a means to the later success. Meanwhile, in anticipation of this, and at the same time utilizing the experience obtained at Philadelphia, another improvement was made, and this is shown in the patent No. 179938, of 1876. In this there was a radical modification and simplification of the whole design, which was thus put on a working basis. In it the brass bearing in the sleeve was made with a ball upon the outside, so that, as it rested in the sleeve, it could assume any angular position relatively to the same, within limits, to accommodate itself to the springing of the axle. It was held in place by a ring driven in from the outside and itself held by a nut. It was prevented from turning in the sleeve by a pin fastened to the latter and projecting down, like a key, into a groove cut in the ball.

The rigid axle was turned off on the bottom to an eccentric bearing of the same radius as that of the box, which was one-thirty-second inch larger than the axle. These axles were of cold-rolled shafting 3¼ ins. in diameter. This gave a large bearing surface on the axle, without the necessity of waiting for wear, and a universally adjustable bearing. The sleeve was formed of two heavy cast-iron ends, into which a connecting piece of heavy wrought-iron pipe was pressed. This to reduce the weight.

Lubrication was obtained by drilling a hole in the end of the axle about ¾ in. in diameter and 13 ins. or 14 ins. deep, from which cross holes were drilled to the bearings beneath the brass. A cork washer at the end packed the joint between the oil box and the axle so as to prevent a leakage of the oil or grease. Then, in order to preserve the cleanliness of the wheels and truck, a projecting collar was screwed on the outside of the hub of the wheel; this led the waste grease back to a receptacle in the bottom of the oil box. The lubrication of the wheel on the sleeve was effected by leakage at the joints through the centrifugal action. It will be borne in mind that the movement between the wheel and the sleeve was very slight, being only that necessary to compensate for the difference in the rotation of the two wheels due to the difference in the length of the rails upon which they were running.

This design was applied to twenty passenger cars on the Gilbert Elevated Railway, now a part of the Manhattan Elevated system, in New York. At that time (1878) the road extended from Rector street to Fifty-ninth street.

These cars were built in Detroit and were run to New York on their own wheels. The lubricant used on this run, as well as thereafter, was the well-known Albany grease. In running from Detroit to New York at speeds of from 30 to 40 miles an hour there was no heating of the journals, and on reaching destination the paint on the wheels was as fresh as when first put on and there was no evidence that a single drop of grease had escaped. The cars were then put into immediate service, and made the run of about 4½ miles in 20 minutes. The road was then operated from 5 in the morning until midnight, so that these cars probably averaged from 150 to 170 miles a day.

Here again no dynamometer tests were made. As far as personal observation is concerned, there was no detectable difference in the ease of motion of the cars with loose or rigid wheels, either on curves or tangents, and so, the actual saving in motive power is unascertainable.

However, it was quite noticeable that the cars drifted around the sharp curves on this line very much more easily than did the trains equipped with rigid axles. Further than this, there was a noticeable reduction in the wear of the treads of the loose wheels as compared with those that were rigid, although both were subjected to the same brake-shoe action. The rigid wheels began to be removed for re-turning after the road had been in operation for a month, while in three months none of the loose wheels needed re-turning.

At one time during the summer of 1878 a test was made in order to ascertain the grease consumption of these cars. The boxes on one were filled, closed and sealed. At the end of six weeks the grease consumption had been about 7 ounces for each journal, and in that time all had run perfectly cool, and nearly all of the grease used had been deposited in the drip beneath the oil box. In short, from a mechanical standpoint the operation was all that could be desired, namely, ease of motion about curves, no grinding of the wheels on curves, reduction of wear of wheel treads, and economy of lubrication.

Owing to personal friction between Mr. Miltimore and the mechanical officers of the road, which need not be detailed here, but which culminated in the removal of all of the wheels from the road, the work was stopped and nothing more on an extended scale was done.

In 1878 Miltimore took out a patent (No. 200746) in which he divided his sleeve and coupled it together after the manner of the old divided axles, but he never built wheels and axles in accordance with this design. It was regarded merely as a protective patent to guard against infringement.

Miltimore's final design is shown in his patent No. 222833 of 1879. In this he abandoned his heavy cast-iron ends for sleeves, and substituted therefor an extension to the inside of the hub of his wheel. The oscillating box was put in the front end of the hub, and so the wheel was now made loose on the axle upon which it turned, and was merely held to gauge by the sleeve.

A collar on the sleeve held the wheels to gauge on the inside, and a nut on the ends of the pipe prevented them from spreading.

A passenger car was equipped with this design and run for a number of weeks on the Harlem Extension Railroad between Chatham, N. Y., and Bennington, Vt. This road is very crooked and has some steep grades.

In building the wheels and axles for this service, the shoulder on the pipe at the back of the wheel hub was first put on by upsetting the pipe in a die. This injured the metal to such an extent that the pipes soon broke and the car was run for several weeks with the sleeves in this condition, illustrating the safety of the device. These shoulders were afterwards formed by shrinking a collar in place; after which no further difficulty was experienced.

The Miltimore axle, as thus designed, was also applied to a horse car on the line between Troy and Lansingburg, N. Y. This was in 1879 and the service was light, but an unexpected difficulty was encountered. The car was put in service early in September and soon earned for itself the reputation of being an exceedingly easy car to haul, as it would pass curves almost as readily as it could be hauled on a straight track; so that it at once became a great favorite with the men. But when cold weather came and stones or frozen dirt were apt to be dropped and left on the rails, it was found that a quick and complete derailment immediately followed the striking of such an obstruction. The car turned so easily that the moment one wheel was stopped or checked in this way those on the other side of the car would run ahead of it, and it was not unusual to have the car run off into the road and not stop until it was at right angles to the track. After a few experiences of this sort the car was withdrawn from service.

The Miltimore wheel can therefore be considered to have been developed into a mechanical success, so far as operation

was concerned. Its fate, then, may be regarded as an exemplification of the difference between a mechanical and a commercial success. It failed because of the excessive first cost, the complication of the details of its construction, the inaccessibility of its parts, and the impossibility of utilizing the ordinary car inspector to watch it and maintain it, as well as because of the fact that, as a general proposition, a loose wheel is not worth while.

The only other loose wheel which, so far as I know, a serious attempt was made to develop was that of Baker. This was put on ten cars on the Gilbert Elevated Railroad in 1878 at the same time as the Miltimore wheel. This was a divided axle, and was the subject of constant and repeated failures for about a month or six weeks, when it was removed. The whole trouble arose from the springing of the axle. There was a cramping of the wearing parts, rapid wear, and heating, with the resultant effect of excessive play and wabbly wheels.

My experience in these matters has led me to the conclusion that a divided axle can not be fastened together with sufficient rigidity to prevent this excessive cramping and, at the same time, permit of the required independence of motion of the two parts. The axle must be allowed to spring and flexible bearings must be provided; and when this is done the first cost and complication of parts prohibit its use.

In considering the value of a loose wheel to a railroad it must be remembered that its only value lies in its ability to compensate for the difference in the length of the two rails without requiring that one of the wheels on the axle should slip on its tread on the rail. Theoretically, there would be no saving on a straight track with wheels of the same diameter. But the two wheels never are of the same diameter, so there is always some slipping in the case of rigid wheels. On curves there is always a slip, but this is the same for the same angular length of curve regardless of the length of its radius, and is equal to a curve of the same angular length, having the distance between the centers of the wheels as a radius, and this may be taken at about 4 ft. 10 ins. Therefore, on any track making a complete circle, whether it be as a circle or with innumerable tangents between successive arcs, as in a belt line whose curves are all in one direction the total slipping will amount to the circumference of a circle whose radius is 4 ft. 10 ins. or 30 ft. 4.43 ins. The expenditure of power to accomplish this will depend upon the coefficient of friction between the wheel and the rail and the load on the wheel. My own investigations lead me to put the coefficient of friction between a cast-iron wheel and the rail at about 0.20 for loads of approximately 20,000 pounds. The extra effort then to move a loaded car of 100,000 pounds capacity, having about 19,500 pounds on each wheel, around a curve that formed a complete circle or one closed on itself would be about 118,443 foot-pounds per axle, or 473,772 foot-pounds for the car, or the development of 1 h. p. for less than 15 minutes. If we take the Miltimore construction as a standard, the extra weight involved would be at ful for any common carrier engaged in interstate or foreign commerce by railroad to use any locomotive in moving interstate or foreign traffic not equipped with an ash pan which can be dumped or emptied and cleaned without the necessity of any employee going under such locomotive. It is made the duty of the Interstate Commerce Commission to enforce the provisions of the act, and a penalty of $200 for each and every violation of the act is provided. The law makes it the duty of the United States district attorney having jurisdiction in the locality where a violation shall have been committed to bring suits for recovery of the penalty upon duly verified information being lodged with him of a violation having occurred, and it is also the duty of the Interstate Commerce Commission to lodge with the proper district attorneys information of any such violation as may come to its knowledge. Locomotives upon which, by reason of the use of oil, electricity, or other such agency, an ash pan is not necessary are excepted from the provisions of the law.

The reports received by the board up to November 1, 1909, cover a total of 50,879 locomotives. Of this number 26,336 are equipped with pans that are designed to meet the requirements of the law. The reports indicate that a further number of 19,676 locomotives are expected to be properly equipped before January 1, 1910. Of the total number of engines reported, 2,813 come under the exception in section 6 of the law as not requiring ash pans, and 25 are to be retired from service before the end of the year.

This leaves 2,029 locomotives, of the total number reported, which apparently will remain to be equipped after January 1, 1910. The roads reported as having locomotives that will not be equipped on January 1, together with the extent of such deficient equipment, are as follows:

Atlantic Coast Line	184
Bessemer & Lake Erie	20
Buffalo, Rochester & Pittsburgh	161
Chicago & Alton	143
Chicago, Milwaukee & St. Paul	340
Chippewa Valley & Northern	2
Cleveland, Cincinnati, Chicago & St. Louis	27
Florida East Coast	61
Green Bay & Western	28
Illinois Central	250
Louisiana Railway & Navigation Co.	30
Manistee & Grand Rapids	4
Missouri, Kansas & Texas	159
New York, Chicago & St. Louis	43
Oregon Railroad & Navigation Co.	65
Oregon Short Line	156
Peoria & Eastern	14
St. Louis Southwestern	17
St. Louis South Western of Texas	34
Southern Pacific—East of Sparks	12
Tennessee Central	14
Terminal Railroad Association of St. Louis	51
Wabash	214
Total	2,029

The drawings of ash pans received from the railroads have been classified, and the board has had them examined by Mr. George L. Fowler, of New York City, a mechanical engineer who has had long experience in locomotive design and operation in general, as well as with the particular devices now under consideration. Mr. Fowler has prepared descriptive and comparative notes concerning each principal class of emptying arrangements, and these notes, with drawings, are given in the appendix. He finds a variety of devices in use, differing somewhat in simplicity of construction and facility of operation, but all thus far examined appear to be of such a character that their use would constitute compliance with the law. As pointed out by Mr. Fowler, the spirit of the act would seem to require the use of an apparatus which not only will probably clear out the contents of the ash pan, but also will be capable of being restored to its normal position, ready for the next operation, without requiring that any person shall go beneath the engine. Some of the devices in use, so far as can be judged by the drawings, will not be satisfactory in this respect.

As to the ash-pan devices of which descriptions and drawings have been presented by inventors to the board, two are in use, and the descriptions indicate that their use would comply with the law. Six others are crude and evidently designed by persons not well acquainted with the problem to be dealt with.

AIR BRAKES AND DETAILS.

Specifications and plans of numerous devices for the improvement of power brakes have been submitted to the board

for examination, but no device has yet been approved. While some of the inventions possess sufficient merit to justify a further investigation, the great majority of them appear to have been designed by persons who are not familiar with the requirements of modern service.

While safety is the prime factor to be considered in the braking of cars, it is not the only one. There must also be sufficient flexibility to permit the making of smooth, accurate stops in the shortest possible distance, combined with simplicity and durability.

Specifications and plans of one complete air-brake system have been submitted and examined, and a preliminary test has been witnessed; and while the apparatus in question has one strong point in its favor, namely that in it the brakes are applied by the pressure of coiled springs and are held off the wheels by air pressure, so that in the event of loss of air pressure, not only in the train line but also in the main reservoir, the brakes are applied by spring pressure, the apparatus was found to be so defective mechanically as to render its use impracticable without further improvement.

The brake referred to is that of the St. Clair Air Brake Company, of Indianapolis, Ind. Its characteristic feature is a powerful coil spring carried in a cylinder, concentric with the brake cylinder and arranged "tandem" with it, and so connected that air pressure from the train line compresses the spring, so that the power therein stored constitutes the primary force for use in applying the brakes. The air pressure, which is normally used in opposition to the springs for holding the brakes released, may be used to re-enforce the pressure applied to the brake shoes by the coil springs. This brake was tested on a train of heavy cars on a steep grade on the Copper Range Railroad July 6 and 7, 1908, and satisfactory reports are furnished of the behavior of the brakes in this test. Air pressure was economized, so that a much larger reserve power was made available for descending a long grade than is practicable with standard air-brake equipment alone. But in the preparations for a test of a 50-car train at La Junta, Colo., on the Atchison, Topeka & Santa Fe, in July, 1909, it was found that the St. Clair brakes did not work properly in connection with the Westinghouse air brakes, which were fitted to a part of the cars in the train. The test was not carried far enough to explain satisfactorily the reasons for the failure of the brakes to work together, but defective workmanship in the distributing valves was one of the reasons. The difficulties altogether were so great that the test was abandoned.

From the data presented the board concluded that the St. Clair brake might work satisfactorily when used by itself in a train, but that it was not expedient to take further action concerning it until the apparatus should be developed so as to make the system operable satisfactorily in the same train with the Westinghouse and New York air brakes. The inherent feature of this system is that in the absence of any air pressure in the cylinders the brakes are set. For moving cars in switching where air pressure is not available, means, not as yet provided by the proprietors, would have to be devised for releasing the brakes to permit movement of the cars.

A number of specifications describing automatic couplers for air, steam, and signal hose have been submitted to the board. The adoption of a practical automatic hose coupling is important to both the railroads and their employees, both as a time saver and as a safety device.*

Automatic hose connectors are now in use to a very limited extent. They are of two general types, one known as the side port and the other as the straight port type. The term straight-port connector is used to designate one in which the contact faces are in a vertical plane at right angles to the track. A side-port connector is one in which the contact faces are in a vertical plane parallel to the track. Both types of connectors have been used for periods of time varying from one to four years, on a number of railroads, and this service has demonstrated that, when properly applied and maintained, either type is practical. This use has been almost entirely in passenger service. This is considered the most severe test, on account of there being three lines of hose to connect. In freight service, where only a single line of hose is required, less difficulty should be experienced in perfecting a satisfactory connector, nothwithstanding the greater length of trains.

Although automatic connectors have been in regular use on several hundred passenger cars on one road for over four years, the service seems still to be looked upon as experimental, a fact which suggests the somewhat complicated nature of the mechanical, financial, and operating problems that are involved in the proposition to adopt automatic hose connectors universally.

This being the situation, this board has as yet taken no action concerning the inventions and proposals that have been submitted to it. Most of the inventors of automatic hose couplers seem to overlook the point that as it is manifestly impossible to equip all cars in service at the same time, any hose connector, to be serviceable, must be so constructed that it can be coupled to couplings now in common use until a sufficient time has elapsed to have all cars equipped. The absence of this feature in any connector is sufficient to prevent its adoption, except in isolated situations. Another important question is the stopping of leaks and making light repairs in yards. In many of the automatic hose-coupling devices which have been examined no provision has been made for doing such work after the cars have been coupled together without separating them, which means that a switching engine must be at hand. This, from an operating standpoint, is clearly impracticable. Other hose connectors which have been examined contain an automatic valve to take the place of the angle cock. This valve is so designed that the flow of air in the brake pipe would be impeded, so much so as seriously to interfere with the proper operation of the brakes.

A number of specifications describing automatic pressure-retaining valves have also been submitted and have been examined. While some of these are well designed and would, no doubt, operate properly when in good condition, it does not seem advisable to recommend the use, on cars generally, of such an addition to the brake system until the railroads' present system of making air-brake repairs can be improved; for the retaining valves would no doubt soon become so defective as to be an element of danger rather than a safety device. In no part of the air-brake equipment are durability and simplicity more desirable than in the retaining valve. The valve on a given car may go unused for long periods of time; yet when it is needed, as on heavy mountain grades, it must be in perfect condition, for in that service it is a vital element in the safety of the train.

Another device which has been submitted for examination by several different inventors is one for locking the brake and holding it applied after it has been applied by the air pressure. While such devices might possibly be of value on special cars, not to be interchanged between one road and another, they are impracticable for general use, chiefly because they destroy the flexibility of the brake system, which is so necessary for the successful and smooth handling of trains.

The foregoing suggestions are not made for the purpose of discouraging inventors or with any idea of limiting their

* In the case of United States v. Boston & Maine Railroad Company, in the district court of the United States for the district of Massachusetts, January 5, 1909, Judge Dodge in his charge to the jury held "that a man engaged in connecting or disconnecting the air hose between the cars is engaged in coupling or uncoupling cars, within the meaning of the statute, if it is necessary for him to connect or disconnect that hose in order to connect or disconnect the cars."

field of work, but rather for the purpose of calling their attention to certain well-established principles which must be observed.

THE "LOOSE WHEEL."

The board has been called upon to consider two inventions aiming to avoid the slipping of one of a pair of wheels mounted rigidly on an axle when rounding curves, thus reducing friction and consequent wear and tear on both wheels and rails. It has long been a favorite idea that by mounting the wheels on the axle independently of each other, the same as on a wagon, much saving of power and of wear would be effected. Loose wheels were thoroughly tried more than thirty years ago, and for reasons based on the experience then had (and which are set forth in the appendix) this board has declined to encourage these later inventions. While some of the designs are meritorious in certain features, they are all necessarily complicated and more expensive to make than the rigid-wheel construction, and much more difficult to maintain.

The extended experiments conducted on the Miltimore wheel and axle between 1870 and 1880 demonstrated that there was a saving in motive power and a reduction of wear as compared with the rigid-wheel construction; but while a mechanical success it can not be said to have been a commercial success. It failed because of excessive first cost, complication in the details of its construction, inaccessibility of its parts, and the difficulties of proper maintenance.

The heaviest and most rigid truck in the train is the engine frame itself, which carries the drivers, and to this the loose-wheel construction is not, of course, adapted; consequently, there must always be the wear and tear on the track structure of the engine itself, equal, presumably, to that of a number of cars. The most, therefore, that could be claimed for the loose-wheel construction would be the saving of power and the wear and tear due to the cars themselves, which can amount to only a part of the total for the entire train.

Allowing everything that could be reasonably expected of the loose-wheel construction, the board is of the opinion that there is not in it a promise of sufficient merit over present constructions to warrant its adoption by the railroads.

Inventions Relating to Track.

The board has examined a considerable number of designs of railway rails, rail joints, ties, and track fastenings of various forms. In by far the greater number of these devices the drawings and descriptions show clearly that the inventors are unfamiliar with the requirements that such devices must meet. Most inventors of rails, for example, do not appreciate the fact that railroad rails can not be punched or have notches cut into them and cannot be formed into various shapes by machining, because of the expense involved and also becouse of the danger of fractures starting at angles. Many inventors attempt to use one form of structure for the support of the track and another for the maintenance of the gauge, whereas economy and good design require that these functions should be accomplished by one member. Many inventors of metal ties make no provision whatever for changing the track gauge, or for shimming the track when, because of the ties becoming frozen into the ground, it is necessary to raise the rails from the tie.

Practically all the inventions in this line that have been thus far considered have been considered unfavorably, except a few of those relating to metal sleepers or ties. Of the tie inventions a number of designs have shown more or less merit, considering them from a purely mechanical or scientific standpoint. But none have been presented by parties who were ready to put their ties in service in track, under conditions which the board deemed satisfactory, and no tests have as yet been undertaken.

The investigation which the board has made concerning the use of titanium in rails is the subject of a brief statement in the appendix. The experiments which have been made in this field by rail makers and inventors are of much interest, both from a scientific standpoint and as measures of economy, but this board must consider them from the single standpoint of safety; and from this point of view, the subject is of only secondary interest, as rails of satisfactory quality can be, and are, made by the old processes without using titanium or any costly alloy.

Conclusions.

The board has given all proper encouragement to every proposition that has been brought to its attention which has appeared to be useful or to embody reasonable hope of being useful for the promotion of the safety of railroad travel or railroad operation. In the investigation of automatic train control the results have been meager, because (except in the two cases mentioned) no one has seen fit to expend the very large sums of money that would be necessary to build and install apparatus for making satisfactory tests of inventions of this class. This board has no authority to spend money for apparatus and can not, therefore, expedite the development even of the devices which it has approved for test. The main features of this branch of the art of railroad operation are pretty well understood, and, aside from making tests in accordance with the law and reporting the results thereof, there is little that the board can do concerning it. The thing needed is experience in severe service. There are as yet no extensive permanent installations which will afford this experience.

The board, therefore, is not at this time prepared to make a definite and positive recommendation for the use of an automatic stop in connection with the block-signal system. It is reasonable to expect, however, that when the systems which have been approved by the board for test have been subjected to severe trial under service conditions and have had any faults which such tests may develop corrected, it will be found that several forms of automatic train-controlling devices are available for use. The art of automatic train control, like the art of signaling, must be developed by those most intimately concerned in its use, namely, the railroads themselves. It is not to be expected that trials or tests conducted by the government will, independently of extended use by railroads, result in the production of devices or systems fully developed to meet all the exacting conditions of railroad operation. The real value of any mechanism can only be demonstrated by its extended use in the place and for the purpose intended. The government, under existing law, can do little more than eliminate those devices and systems which are obviously unsatisfactory, present in concise form such information as it may gather in regard to the question, and indicate through the published results of examinations and tests a line of effort which it is believed will, if followed by the railroad companies themselves, result in the practical development of automatic train control to a point where it will at least serve materially to diminish the wofully large number of accidents which might be prevented by the use of reliable automatic train-controlling devices.

In block signaling proper no important new propositions have been brought out, except the A B C system (and that has been investigated by the board on its own motion), and the only action taken has been such as was deemed necessary to keep informed concerning the practice of the railroads generally in this respect. As has been stated, the practice in "telegraph" or manual block signaling is in many places open to criticism. For the correction of this unsatisfactory practice the most feasible governmental measure is the establishment of regular supervision over all interstate carriers in this respect. This has been heretofore advocated

by the commission and has been embodied in bills presented in Congress to enforce the use of the block system and to investigate train accidents. By the passage of these bills the way can be opened for the establishment in this country of the very praiseworthy methods in signaling and in other features affecting safety which are in vogue in Great Britain, and which have produced the remarkable freedom from accidents recently recorded in that country.* These safety measures were epitomized on page 69 of our last annual report, those pertinent to our present purpose being—

1. Careful selection and thorough training of block signalmen.

2. Constant, regular, and thorough inspection of manual block signal operation and methods.

3. Proper inclosing of railroad tracks, together with the enforcement of laws against trespassing thereon.

4. The payment of pensions by railroad companies to their superannuated employees.

5. The compulsory use of a space interval in train operation.

The first two of the foregoing heads have been touched upon. The third, the question of dealing with trespassing, is less directly connected with train operation; but with 5,000 or 6,000 trespassers killed on the railroad tracks of the United States every year, the nonenforcement of the laws against trespassing must be looked upon as a crying evil, demanding the attention of every governmental agency that has any power in the premises.

The ground connection used is unique. We are not informed as to its efficiency, but it would seem that an ordinary iron rod or two if needed, driven into the ground, would serve the purpose equally well and be decidedly cheaper.

Losses Due to Railway Strike in France.

L'Officiel recently published a statement of the losses in receipts sustained by the state and other railway companies in the recent strike in France.

It had previously reported that for the forty-first week of 1910, when the strike was broken, there was a deficit of 3,379,000 francs ($675,400) in the receipts of the six great companies. The loss was still more during the forty-second week. The following table shows the amount and percentage by which the receipts for the period were less than for the corresponding period of 1909:

Western-State	1,130,000 fr. ($226,000)	or 26.5 per cent
Northern	2,002,000 fr. ($400,400)	or 35.7 per cent
Paris, Lyons & C.	670,000 fr. ($134,000)	or 5.5 per cent
Eastern	620,000 fr. ($124,000),	or 12.6 per cent
Orleans	577,000 fr. ($115,400)	or 9.8 per cent
Southern	463,000 fr. ($ 92,600)	or 18.2 per cent
State (old)	88,500 fr. ($ 17,700)	or 6.9 per cent

The second week of the strike caused a loss to the state and the companies of more than 5½ millions. Then, in addition to this total, the strike cost the state 9,000,000 francs ($1,800,000) either directly or indirectly in interest guaranteed for the other companies, and that without taking into account the losses of commerce, manufacturers and agriculture, because of the suspension of the facilities of transportation.

Fatal Explosion of Gas at the Grand Central Terminal, New York.

By an explosion of gas on the morning of Monday, December 19, the substation of the power system of the New York Central, electric division, at Fiftieth street, New York city (the northeast corner of the terminal yard), was almost completely demolished, and windows were broken in scores of buildings within a radius of half a mile. Ten or more persons were killed and over 100 seriously injured, some of the killed being passengers in a street car which was passing at the time and which was overturned by the force of the blast. Agents of the plate glass insurance companies estimated that their losses in the region of the explosion would amount to $25,000.

*In the year 1908 (as in 1901) no passenger was killed in a train accident on any railway in the United Kingdom, and only six employes were killed in such accidents.

The Minnesota Railroad Commission at St. Paul December 20 last held a conference with seven signal engineers and three representatives of signal departments—10 railways in all—on the question of drafting a suitable law for Minnesota to regulate the protection of crossings by interlocking. It was decided to have the question investigated, with a view to seeing if the laws of Illinois and of Canada on this subject would be suitable for Minnesota. The chairman of this committee of signal engineers will be Mr. Jorgenson, engineed of the Minnesota commission.

The Union station at Newcastle, Pa., was destroyed by fire December 13. Estimated loss, $40,000. This station was occupied by the Pennsylvania, the Erie, the Baltimore & Ohio and the Pittsburg & Lake Erie.

The electrification of Chicago railway terminals was taken up by the Chicago city council on December 19. The president of the Association of Commerce presented a formal announcement that a committee from that association had carefully considered this problem and now desired the aid of the city. In accordance with this request, the mayor appointed four members of the council to co-operate with that committee. At the same meeting an ordinance was introduced to compel all steam roads to electrify their lines throughout a radius of seven miles from the city hall, the work to be completed by January 1, 1913. No action was taken on the ordinance.

Curtis Dougherty, who was recently promoted from engineer maintenance of way to chief engineer of the Cincinnati, New Orleans & Texas Pacific and the Alabama Great Southern, with office at Cincinnati, Ohio, was born July 30, 1863, in Jersey county, Illinois. He graduated as a civil engineer from Washington University at St. Louis in 1885, and began railway work in the following year with the Wisconsin Central. For four years from 1888 he was an engneer on the Chicago & Western Indiana; he then went with the Illinois Central, first as roadmaster, and later as superintendent, remaining with that road until 1907. His next position was assistant chief engineer of the Cincinnati, New Orleans & Texas Pacific and the Alabama Great Southern. In 1908 he was promoted to contracting and consulting engineer, and in 1909 engineer maintenance of way, from which position he was promoted to chief engineer on November 1, 1910.

A. F. Blaess, roadmaster of the Illinois Central at Louisville, Ky., has been appointed assistant engineer maintenance of way, with office at Chicago, succeeding L. A. Downs, appointed superintendent at Fort Dodge, Iowa.

A New Use for Motor Cars.

The agricultural experts from the colleges of Missouri and Kansas, apparently the two states combined, made a trip over the Kansas City, Clinton & Springfield recently. The professors and lecturers traveled in a train of three Fairbanks-Morse gasoline motor cars. The expedition was highly successful; nearly 5,000 farmers listened to the lectures, in which were included the subjects of poultry raising and good roads. The expense of this train was of course much less than would have been required to run a locomotive and full sized cars.

Upper Berths.

The papers are cheering rather loudly about the great victory over the Pullman company, but it happens that there are experienced travelers who ask for the upper when they journey; it has its advantages. But the meanest thing is the order that when a passenger buys a lower berth the porter who makes it up for him must at the same time drag down and make up the upper unsold and undesired. It is the same in principle as if the railway required the brakeman to dump a bag of potatoes beside every passenger in the ordinary coach who had a seat all to himself, the bag to be left there until somebody came along who needed the place, unless the passenger could produce two tickets. The only defense that has been attempted for this extortion is that otherwise porters will for a bribe leave the uppers up and discourage those who would buy them. But the idea of kicking at the public giving money to Pullman porters; it's the way those fellows get their pay and the company knows it.—*Hartford Courant.*

The L. J. Smith Locomotive & Equipment Company has recently been organized at Kansas City, Mo., and acquired a plant on Fourth and Central streets. In addition to general repair work on locomotives, steam shovels and contractors' equipment of various kinds, the company will deal in such machinery, utilizing its facilities, when necessary, to put apparatus in good condition for resale.

Walter L. Pierce, who for thirty-two years had been connected with the Lidgerwood Manufacturing Co., and for twenty-nine years its secretary and general manager, died suddenly of heart failure at his winter home in the Hotel St. Andrews, New York City, Saturday morning, December 10, 1910. He was a son of John F. Pierce and was born at Dorcester, Mass., on June 8, 1855. He was remarkable as an organizer and so perfect was his work that no detail of the great business which he built up was neglected during his long absences while seeking health. The organization which he formed is a monument to the efficiency of his work. Besides his connection with the Lidgerwood Manufacturing Co., he was treasurer of the Hayward Co., and of the Gorton-Lidgerwood Co. He was a member of the Lawyers' Club, the Engineers' Club, the Machinery Club, in which he was also a director; an associate member of the Naval Architects and Marine Engineers and of the American Society of Mechanical Engineers, and a past president of the National Metas Trades Association.

W. L. Mattoon, assistant engineer of the Hocking Valley at Columbus, Ohio, has been appointed real estate agent in charge of taxes, with office at Columbus.

J. W. Kendrick, vice-president in charge of operation of the Atchison, Topeka & Santa Fe, with office at Chicago, has been granted a six-months' leave of absence, during which time he will take a trip around the world. W. B. Storey, vice-president in charge of construction, will assume Mr. Kendrick's duties temporarily.

Encouraged by the success of the farmers special instruction trains which it has been operating during the past three years, the Pennsylvania on December 5th and 6th carried the gospel of scientific farming a second time to the farmers in the territory tributary to the Pope's Creek branch of the Maryland division. During last winter's educational campaign for improved methods in agriculture a special train was run over this same portion of the road. Much interest was aroused among the farmers and many requests for another educational train have been received.

The Pennsylvania inaugurated its campaign for intensive farming three years ago and since that time a large number of special trains and steamboats have been operated on various divisions. The company is confident that these trains have been productive of much good and that they will eventually become great traffic producers in that the farmers will secure better yields from their land than they are securing to-day. The state colleges are co-operating with the railroad by giving the time of their professors, who talk to the farmers and answer their questions.

New Station at Jamaica, N. Y.

To provide for the largely increased passenger traffic to and from Jamaica, due to the opening of the Pennsylvania station in New York, the Long Island has started the construction of a new station at Guilford street and Archer place. The building is to be 70 feet by 174 feet. It will be four stories high, with a temporary roof built so that four additional stories can be added. It will be fireproof throughout, built of steel skeleton on concrete foundations. The walls will be faced with dull glazed terra cotta. The main waiting room will be decorated with rookwood faience tile, and the various retiring rooms will be made to conform. Leading from the waiting room to the station platforms will be a tunnel beneath the tracks. This will be used by passengers going to and from trains. The platforms will be protected with umbrella sheds. The new Jamaica station will be merely a part of the scheme of improvements which the Long Island is making at that point. Various crossover tunnels are being built so that no tracks will cross others at grade. It is expected that the station work will be completed by the spring of next year, while the other work on the Jamaica improvement will not be finished until later.

The Union Pacific is building mechanical interlocking plants at South Omaha, Neb., and Quimby, Colo. Each machine will have ten working levers.

The Cumberland Valley has let a contract for the installation of automatic block signals on 44 miles of double track.

The Boston & Maine proposes this year to install automatic block signals on 423 miles of its lines. On 324 miles of this, the work is already half done.

The Northern Pacific has electric block signals under construction on about 200 miles of double track. The manual block system is now in operation on these lines.

The plans of the Chicago & Eastern Illinois for this year includes the installation of a mechanical interlocking plant at Hudgens Junction, Ill., and one at West Vienna, Ill., each to have 14 working levers.

The Oregon Railroad & Navigation Company expects to instal automatic block signals on 55 miles of its line this year. There is a length of 14 miles of single track road which will be made double track, necessitating a corresponding change in signals.

The Great Northern plans to install automatic block signals on 56 miles of double track, and manual signals on 57 miles of single track. Three mechanical interlocking plants are also planned. They will be at Everett, Wash.; Summit, Mont., and Java, Mont., each 16 levers.

The Chicago, Burling & Quincy intends to install instruments for controlled manual block signaling on the lines from Hastings, Neb., to Denver, Colo., 368 miles; Napier, Mo., to Lincoln, Neb., 112 miles; and from Lincoln, Neb., to Huntley, Mont., 825 miles. At present the simple telegraph block system is in use on these lines.

The Southern Pacific (Pacific System), expects to install automatic block signals this year on 107 miles of its line. Electric interlocking plants will be installed at Sacramento, 20 levers; at Elvas, 52 levers; at Dolgeville, 20 levers; at Alameda, 2 machines, one of 24 levers and one of 17 levers; at Fruitvale, 80 levers; at Berkeley, 2 machines, one of 20

levers and one of 28 levers, and at Albany one of 24 levers. Electro-pneumatic interlocking plants will be installed at Los Angeles, 59 levers, and at Oakland, 3 plants of 71 levers, 17 levers and 15 levers, respectively.

William Michel has been made chief engineer of the Hocking Valley, with headquarters at Columbus, O.

John A. Megrew, inspector of maintenance of way of the Delaware & Hudson, at Albany, N. Y., has been appointed superintendent of the Saratoga and Champlain divisions, with headquarters at Albany.

Louis L. Johnson, formerly gas engineer, in the electric department of the Southern Pacific at San Francisco, Cal., has opened an office as a consulting engineer on gas, power and fuels, at Indianapolis, Ind.

Curtis Dougherty, engineer maintenance of way of the Alabama Great Southern and the Cincinnati, New Orleans & Texas Pacific, at Cincinnati, Ohio, has been appointed chief engineer of both companies at Cincinnati, and his former position has been abolished.

MINE RESCUE STATIONS IN ILLINOIS.*

By R. Y. Williams.

The discussion of any problem affecting coal mining methods applicable to such a state as Illinois is of considerable interest, because Illinois stands second in the list of the twenty-seven coal-producing states, and holds in reserve more bituminous coal than any other state in the Union. It is also the second largest producer of bituminous coal. This position, however, has been attained by the sacrifice of many human lives and the loss of millions of tons of coal. The indefinite continuance of these conditions would be most unfortunate. But coal mining engineers are facing these problems seriously. Already the explosiveness of coal-dust has been demonstrated, methods of its control investigated, a list of permissible explosives has been published by the government, and a paper on some phase of the efforts now being made for the conservation of that greatest of all natural resources, human life, it is believed will be of value.

The investigations in this field are proceeding along two lines—the prevention of mine accidents and the work of mine rescue. While the first is by far the more important problem, it is nevertheless apparent that calamities such as mine explosions and fires are of such frequent ocurrence as to be a constant menace to the safety of the man and of the mine. For these reasons the work of rescuing life and saving property are urgent problems in present-day coal mining. With this in mind, the following has been written in an endeavor to present a general scheme for Joint Mine Rescue Stations in Illinois.

Early in March, 1909, the United States Geological Survey, in co-operation with the State Geological Survey and the University of Illinois, established at Urbana, Illinois, a mine rescue investigation station which is a branch of the Central Testing Station at Pittsburg, Pa. This sub-staton is equipped with oxygen helmets and has a gas-tight room resembling a coal mine, in which miners may test the efficiency of modern breathin appliances. Already this mine rescue laboratory has been visited by many operators and inspectors; a large number of miners have been trained in the theory and practice of rescue work; and considerable assistance has been given on the occasion of several mine fires and explosions. One station, however, cannot render adequate service in a state having more than 400 large shipping mines scattered throughout an area of 275 by 180 miles. In fact, it was not the intention to establish at the Urbana station a permanent rescue corps to act in the event of mine disasters in ordinary rescue work. This station was established primarily to supply the equipment and trained assistants required for the study by the survey experts of mine explosions in the Illinois-Indiana-West Kentucky coal field, and in the hope that the station would offer a means of demonstrating modern mine rescue practice to the mining fraternity of this field.

When an explosion or fire occurs in a coal mine, conditions are usually such as to require that the men entering the mine be protected by helmets, which must be supplied as quickly as possible. It is, therefore, necessary, both for rescue and investigation work, that stations should be within easy reach of each important coal field or division of the field, so that the trained experts can reach and enter the mine promptly following the disaster. Were each mine in the state equipped with a complete rescue station and manned with a corps of trained rescuers, we would have ideal conditions for the recovery of life and preservation of property after a calamity. But, unfortunately, these stations are quite expensive; equally unfortunate, the present selling price of coal is so low that the small margin of profit is already a matter of much concern, so, unless some remedy for this condition can be found, but few individual mine owners, I fear would feel warranted in authorizing such an expenditure of money. In order to overcome this obstacle and still obtain the benefits of modern minerescue methods, the suggestion of joint rescue stations, it is believed should be of great value.

In general, by a joint rescue station is meant one specially designed and equipped for a particular group of mines; located centrally to each of such mines by natural or special transportational facilities, and financed either on a "per ton" or a "share and share alike" basis by each mine benefited. At such a station, at stated intervals, a squad of men from each mine could report for training in rescue methods under the direction of an experienced instructor, assisted if possible by a physician. From such station the rescue paraphernalia could be furnished in the event of a calamity befalling any mine of the group without delay. There are four divisions of the subject which may be amplified:

I. Design and equipment of a joint rescue station.

II. Character of the training to be given at the station.

III. General advantages that may be derived from the stations.

IV. Plan for rescue stations.

1. Breathing appliances were invented abroad and their use established long before we in this country recognized their value. But if we study the design and equipment of these foreign stations, we might be discouraged in an endeavor to copy them. Conditions abroad and in this country are entirely different; and valuable as is a study of foreign methods, we could not afford the luxury of such structures as the Howe Bridge Station in England. There are, however, certain requirements that must be followed in design. The station building should contain a gas-tight room, forty feet long by twenty feet wide and ten feet high. The interior of this room should be fitted to resemble a mine and to afford opportunity for the practicing miner to do work similar to that required in the event of an actual disaster.

(To be continued.)

*This paper was written in December, 1909. On the 14th of that month Mr. F. W. DeWolf, Director of the State Geological Survey, and the author were in Springfield discussing the ways and means to increase interest in mine rescue work. The idea occurred of dividing the state into three sections and asking the state legislature for an appropriation for creating and maintaining three rescue stations. We worked out the details there and then, came to Chicago to lay the matter before the Mine Commission and certain of the coal operators, with the result that a bill was introduced in the Senate which became a law. This bill increased the appropriation from $60,000.00 to $75,000.00 and changed the governing board of five members to a commission of seven.

†A paper read before the Western Society of Engineers.